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ANNALS

OF

The Entomological Society of America

VOLUME III, 1910

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HERBERT OSBORN, Managing Editor,
Columbus, Ohio.

PUBLISHED QUARTERLY BY THE SOCIETY

COLUMBUS, OHIO

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Volume III. Number 1.

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MARCH, 1910

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Address

ANNALS ENTOMOLOGICAL SOCIETY OF AMERICA,
Biological Building, O. S. U., Columbus, Ohio

WM H. EDWARDS

Plate I.

ANNALS

OF

The Entomological Society of America

Volume III — MARCH, 1910 — Number 1

MINUTES OF THE BOSTON MEETING.

The Fourth Annual Meeting of the Entomological Society of America was called to order by the President at 10:30 A. M., December the 30th, 1909, in the buildings of the Harvard Medical School in Brookline.

The President announced the deaths of the following Fellows and Members:

William Henry Edwards, Honorary Fellow, April 4, 1909.

Mark Vernon Slingerland, Fellow, March 11, 1909.

Braxton Honoré Guilbeau, January 16, 1909.

William Brodie, August 6, 1909.

H. M. S. Seib, August 28, 1908.

The minutes of the last meeting were accepted as printed in the ANNALS.

The President announced the appointment of the following committees:

Committee on Resolutions: Messrs. Satterthwait & Brues.

Committee on Nominations: Messrs. Gillette, C. W. Johnson and Burgess.

Auditing Committee: Messrs. Field, Johnson and Sanderson.

Committee to Draft Suitable Resolutions Concerning the Death of Mr. Edwards: Messrs. Newcomb, Wheeler and Field.

Committee to Draft Suitable Resolutions Concerning the Death of Professor Slingerland: Messrs. Comstock, MacGillivray and Riley.

The following report from the Executive Committee was read by the Secretary-Treasurer, and adopted, the constitutional amendments to be brought up at the next annual meeting.

Report of the Executive Committee,

December 30, 1909.

The following six persons were elected members in June:

E. W. Berger,
W. A. Thomas,
R. A. Cooley,
E. H. Smart,
V. I. Safro,
W. O. Strong.

Ten more members were elected at the meeting of the committee yesterday:

Miss E. A. Newell,
Mr. A. C. Lewis,
Mr. W. W. Chase,
Mr. S. F. Blumenfeld,
Mr. P. E. Smith,
Mr. T. C. Barber,
Mr. W. V. Reed,
Dr. C. G. Hewitt,
Mr. J. W. Hungate,
Mr. W. H. Shideler.

The following resignations have been accepted and memberships terminated:

Rev. G. Birkmann,
Mr. C. F. Groth,
Mr. G. H. Chadwick,
Mr. M. Rothke,
C. E. Brown,
A. Ellsworth,
E. C. Greene,
T. D. Jarvis,
J. M. Rankin,
C. Stevenson,
A. J. Meidt,
Mr. C. L. Pollard,
Miss A. M. Fielde,
Mr. F. M. Needham,
J. P. Baumberger,
J. P. Cockburn,
E. Gerstenhorn,
J. C. Huguennin,
R. E. Lea,
W. D. Richardson,
W. L. Tower,
A. F. Winn.

The Executive Committee proposes to the Society for its consideration the following amendments to the constitution to be brought up at the next annual meeting.

To amend Section I of Art. IV, by striking out the words "and a Secretary-Treasurer" and inserting in their place the words "a Secretary and a Treasurer; but these last two offices may be held by the same person, so that the section will read: Art. IV. Officers. The officers of this Society shall be a President, two Vice-Presidents, a Secretary and a Treasurer; but these two last offices may be held by the same person."

To amend Art. IV., Sec. 3, to read:

"Sec. 3. Councilor to the American Association. The President and preceding Past-President shall represent the Society upon the Council of the American Association for the Advancement of Science."

To amend Art. IV, Sec. 2, by striking out the word "who" and inserting after the words "additional members" the words "five of whom" and by inserting after the word "Society" the following: "and the sixth shall be, *ex officio*, the Managing Editor."

So that the Section will read:

"Art. IV, Sec. 2. The business of the Society not otherwise provided for shall be in the hands of an Executive Committee, consisting of the officers named in Section I, and of six additional members, five of whom shall be elected from the Fellows by the Society, and the sixth shall be *ex officio* the Managing Editor. Four members of the committee shall constitute a quorum."

The committee farther recommends an amendment to the proposed amendment to Art .V, by inserting at the end thereof the following: "Their term of office shall commence with the first of June following their election."

During the year a memorial drawn up by Mr. W. C. Wood regarding the tariff on insects and signed by the President and Secretary-Treasurer, was sent to the Honorable Sereno E. Payne. No action by Congress resulted.

Classified Expenditures

Notices, programs, etc. (Society)		$ 10.25	
Stationary (Society)	$ 24.61		
And Stamps	9.25		
Annals, postage and stamps for Annals	13.00	46.86	
Clerks and Stenographers (Society)	8.75		
(Annals)	8.00		
		16.75	
Printing Annals, 4 issues, 1000 copies each	$522.50		
12 Half-tone Inserts	55.00		
		577.50	
Engravings and electrotypes		61.62	
Express and Drayage (Annals)		14.74	
Reprints		138.45	
Total			$866.17
Balance on hand December 1, 1909			147.47
			$1013.64

Of the above total cash expenditures $43.61 were for the general expenses of the Society and the remaining $822.56 were for expenses connected with the Annals. In addition to the

total cash expenditures $866.17, there are debits on the ledgers to Society $54.00 and ANNALS $12.00, total $66.00, representing cancelled subscriptions, and the offsetting of dues of deceased and dropped members, etc.

CASH RECEIPTS.

Balance on Hand Dec. 15, 1908	$108.44	
Receipts from members (excluding 10 cents refunded to Brimley	723.25	
Subscription from non-Members (excluding $3.00 returned)	137.10	
Sale of Reprints and from Excess Engraving Charges Refunded	44.75	
		$1013.54

ASSETS.

Balance from 1908. From Managing Editor	10.67	
From Society and Annals	264.27	
		$ 274.94
Annals: Subscriptions from non-members.*	141.10	
Subscriptions from members	320.00	
Sale of Reprints and Refunded Excess Engraving Charges	44.75	
		505.85
Society. Dues from members	487.00	
Life membership fees	100.00	
Gift from S. Henshaw	6.00	
		593.00
Total Assets		$1373.79

From this sum $66.00 debits representing subscriptions cancelled and the offsetting of dues of deceased and dropped members, etc., should be deducted, leaving $1,307.79 as the substantial assets at the close of the year, and leaving a balance of $339.55 unpaid assets to carry forward.

The Society had no liabilities at the end of the year except $48.30 paid by members for dues and subscriptions for 1910.

Nov. 30, 1909. Unpaid assets		$339.55
Nov. 30, 1909. Cash on hand	$147.47	
Less Liabilities	48.30	
Cash Assets		99.17
Total Assets forward		$438.72

This shows a healthy increase in the total assets carried forward of $162.78 over 1908. In comparison of the accounts with 1908, it must be remembered that that year included the expenses of but three issues of the ANNALS, while the present accounts include four issues, or one full volume. However, there are about 75 members who are now two years in arrears, having paid only

* Foot-note. The Report of the Managing Editor does not show whether there are unpaid subscriptions which would increase this sum.

the one year's fee when they were first elected or became Charter members. In all probability, many of them will eventually have to be dropped for the non-payment of dues, so that somewhere up to $150.00 of the present uncollected assets can not be counted on as materializing.

The appended resolution on the death of Professor Slingerland was read and adopted.

The following papers were read:

F. M. Webster: A Predaceous Mite, *Pediculoides ventricosus* producing a Dermatitis in Man. (Read by Prof. Osborn).

R. Matheson: Remarks on the External Anatomy of the Haliplidae.

Miss A. H. Morgan: Some Correlations of May-fly Structure and Habit.

C. J. Triggerson: The Life-cycle of the Oak Hedgehog Gall-fly (Acraspis erinacei).

H. H. Lyman: An improved Drawer for Insect Cabinets and a New Substance for Lining Them.

A. D. MacGillivray: The Female Reproductive Organs of *Corydalis cornuta*.

The Managing Editor gave a brief report for the Editorial Board; summarizing the work of the year. Four numbers of the Annals have been issued with nearly 300 pages of text and twenty-nine plates. The list of outside subscriptions, has been increased and includes many of the principal libraries. Most of these subscriptions are continuous and we may expect further additions as the publication becomes known. Members who are so located that they can influence librarians in placing the Annals on their permanent periodical list, can assist the growth of the publication by effort in this direction. Moved and carried that the report be accepted.

The Society then adjourned till 2 P. M.

At that time, the President, in calling the meeting to order, spoke of the approaching first International Congress of Entomology at Brussels, Belgium. It was suggested that delegates from this Society be appointed, and there being no objection, this was referred to the Executive Committee.

The following papers were read:

W. M. Wheeler: On the Effects of Parasitic and Other Kinds of Castration in Insects.

W. L. W. Field: The Offspring of a Captured Female of *Basilarchia proserpina*. To be published in Psyche.

F. L. Washburn: A Jumping Seed-gall on the Burr Oak.

The Society then adjourned to inspect the entomological exhibition, which was in conjunction with and under the auspices of the Cambridge Entomological Club.

At 8 p. m., the Annual Public Address was given by Dr. John B. Smith, in the lecture hall of the Boston Society of Natural History. "Insects and Entomologists: Their Relations to the Community at Large."

An abstract of this address appears elsewhere in this number of the Annals.

At 10 a. m., December 31st, the Society was again called to order by the President, Dr. Skinner.

The appended resolutions on the death of Mr. Edwards were read by Dr. Wheeler and adopted.

The President remarked upon the travels of Mr. Edwards on the Amazon River, and the high character of the volume descriptive of that trip, which Mr. Edwards had published, many years ago, under the title "Voyage up the Amazon."

Mr. C. T. Brues read a paper entitled, "Some Notes on the Geological History of the Parasitic Hymenoptera."

The Nominating Committee made its report and the Secretary was directed by vote of the Society to cast a ballot for the entire list thus placed in nomination.

The officers thus elected were as follows:

President, John B. Smith.

First Vice-President, Dr. S. A. Forbes.

Second Vice-President, Prof. V. L. Kellogg.

Secretary-Treasurer, Mr. C. R. Crosby.

Additional Members of the Executive Committee:

Prof. J. H. Comstock,	Prof. J. M. Aldrich
Dr. W. M. Wheeler,	Rev. Prof. C. J. S. Bethune,
Mr. E. A. Schwarz,	Prof. Lawrence Bruner.

Member of Committee on Nomenclature to serve three years:

Prof. T. D. A. Cockerell (to succeed himself).

The following report from the Auditing Committee was read and accepted.

REPORT OF THE AUDITING COMMITTEE.

BOSTON, MASS., Dec. 31, 1909.

To the Entomological Society of America:

Your Auditing Committee has examined the books of the Treasurer and the Managing Editor of the Annals and find them in satisfactory condition.

Your committee recommends that the manner of keeping the financial records of the Society be referred to the Executive Committee to determine the future policy.

Your committee wishes to express the thanks of the Society to the Treasurer, J. Chester Bradley, for the painstaking manner in which the accounts of the Society have been kept.

(Signed) E. D. SANDERSON,
C. W. JOHNSON,
For the Auditing Committee.

The following report was read and adopted:

REPORT OF THE COMMITTEE ON RESOLUTIONS.

The Resolution Committee begs to submit the following resolutions:

Resolved, That we extend thanks to the local committee on arrangements, the Cambridge Entomological Club, the Boston Society of Natural History, the corporation of Harvard University and the faculty of the Harvard Medical School for their many privileges and courtesies accorded us.

Resolved, That the editorial management of the ANNALS of the Entomological Society of America, especially Professor Herbert Osborn, be highly commended for the excellent standard which they have maintained in the publication.

Resolved, That an expression of thanks be extended to Dr. John B. Smith for his admirable public address delivered in the hall of the Boston Society of Natural History.

Resolved, That we also express our appreciation of the untiring work of our Secretary, Mr. J. Chester Bradley.

(Signed) C. T. BRUES,
A. F. SATTERTHWAIT.

The other members of the Committee on Nomeclature being absent, Dr. Felt stated that owing to the prolonged illness of one member of the committee and the somewhat extended absence

from the Country of another, it had been impossible for the committee to formulate any conclusions which could be reported upon at the present time.

The report of the Committee on Nomenclature made to the Baltimore Meeting and printed in the Annals for 1909 was read and adopted, with the provision that the Society express itself as standing with the majority of the Committee in Section V.

Mr. Brues suggested that Professor Felt submit a list of names of Gall Insects that he thought could be accepted as standard.

Mr. Sanderson moved that the request from Dr. Stiles for the preparation of a list of one hundred important names to be adopted by the Congress of Zoology as standard be referred to the Executive Committee. This motion carried.

The following amendment to the constitution proposed at the Baltimore Meeting, was read:

"Art. V, Sec. 3, to omit the following: "All officers, Secretary-Treasurer excepted, and all additional members of the Executive Committee shall be chosen from the list of Fellows. Provided, etc." The Secretary, in accordance with the recommendation of the Executive Committee moved to amend the amendment by adding the words at the end of the section: "Their term of office shall commence with the first of June following their election." Amendment to the amendment and original amendment carried, so that the Section now reads.

"Article V, Sec. 3. Election of officers. All officers shall be elected by ballot at the annual meeting for the term of one year and shall be eligible for re-election. Their term of office shall commence with the first of June following their election.

The Secretary was instructed to take a mail vote of all members and Fellows of the Society as to whether the present arrangement for separate dues and subscriptions to the Annals should remain in force, or whether they should be combined into a single membership fee of two dollars with the provisions that all members should receive without further expense the publications of the Society.

Prof. Sanderson suggested the adoption of a uniform style of button for both the entomological Societies meeting during Convocation Week. Referred to the officers with power.

The following papers were read:

J. C. Bradley: The Plaiting of the Wings of Hymenoptera.

T. J. Headlee: An Apparatus for the Determination of Optimums of Temperature and Moisture for Insects.

A. D. MacGillivray: The Radial Sector in *Phlebatrophia mathesoni*.

W. T. M. Forbes: A Structural Study of Some Caterpillars.

A. G. Hammar: Notes on the Life-History of *Fidiobia flavipes* Ashmead, an Egg Parasite of the Grape Root-Worm *Fidia viticida* Walsh.

In the absence of the authors the following papers were read by title only:

C. R. Crosby: Some Observations by the late Professor Slingerland and the Speaker on the Life-history of *Heterocordylus malinus* Reut.

M. J. Elrod: The Blackfoot Glacier as an Entomological Burying Place.

J. J. Davis: *Chaitophorus populifoliae* Fitch versus *Chaitophorus populifoliae* Oestlund.

L. Haseman: The Life-history of a Species of Psychodidae.

The Society then adjourned, to meet during Convocation Week of 1910 in Minneapolis.

J. Chester Bradley, *Secretary-Treasurer.*

RESOLUTIONS

On the Death of William H. Edwards.

Whereas, By the death of William H. Edwards the Entomological Society of America has lost one of the most illustrious of its Honorary Fellows, and

Whereas, Mr. Edwards, through his magnificent and epoch-making contributions to our knowledge of North American Lepidoptera was widely known as an investigator and author of the first rank; therefore, be it

Resolved, That this Society express, through these resolutions, its grief at this loss to the scientific world, and be it further

Resolved, That these resolutions be recorded in the Annals of the Society, and that the Secretary be instructed to send a copy of the same to the bereaved family of the eminent entomologist.

(Signed) H. H. Newcomb,
W. M. Wheeler,
W. L. W. Field.

MARK VERNON SLINGERLAND

Plate II.

RESOLUTIONS

On the Death of Professor M. V. Slingerland.

Mark Vernon Slingerland, naturalist, economic entomologist, Fellow of this Society, died at his home in Ithaca, N. Y., March 11, 1909. His death is a serious loss to the world of natural science. As a student, his career was marked by earnestness, courage and industry. As a teacher he was direct and forceful. As an investigator he was conscientious, unbiased, persevering and accurate, and his authority and leadership as an economic entomologist received unquestioned recognition.

His memory is cherished as that of a man whose life, though short, stands as a notable example of one who gave his years unselfishly and devotedly to the discovery of useful truths in the realm of natural history in their relation to the economy of plant and animal life. We, his colleagues, give expression to our sorrow in the loss of a friend and fellow worker.

(Signed) J. H. Comstock,
A. D. MacGillivray,
William A. Riley,
Committee.

INSECTS AND ENTOMOLOGISTS:

Their Relations to the Community at Large.

By John B. Smith, Sc. D.

(*Abstract*)*

The importance of insects in their relation to the community at large has only become recognized during recent years, and the work of the entomologist is only now receiving the appreciation it merits. Entomologists in the sense used in the address include systematists, students of life histories and ecology and collectors; but not those studying only anatomy or histology or insects purely as hosts for disease-producing organisms.

Insects are injurious to man directly, as parasites, or as predatory forms attacking him, *e. g.*, lice in the one case, biting flies in the other. Incidentally he may be harmed by urticating larvæ or such as shed barbed hair, like the brown-tail caterpillars.

Insects are further injurious as carriers of, and intermediate hosts for, disease-producing organisms: two totally different processes for, in the first case, the insect has no necessary relation to the disease, *e. g.*, the house-fly to typhoid fever, while in the second the insect is a fellow sufferer, and the disease organism requires both man and insect to complete its life cycle, as in the case of the Plasmodia causing malarial diseases. The relation of mosquitoes to fevers, of flea to plague, and of Tsetse flies to the sleeping sickness was illustrated, and it was stated that if all dipterous insects, including fleas, could be at once eliminated, mankind would be at once freed from malarial, yellow, dengue, jungle, and several other kinds of tropical fevers, the bubonic plague, sleeping sickness, filariasis, several forms of eye diseases, certain ulcerating sores of tropical countries, and we would reduce to a minimum enteric fevers of all kinds, lessen the death rate from tuberculosis and pulmonary troubles, and probably modify or lessen leprosy and kindred diseases.

* This address was delivered before the Entomological Society of America and its friends on the evening of December 30th, 1909. It was a popular presentation of the subject, profusely illustrated by lantern slides, and not suitable as a whole for publication in a Scientific Journal.

All domesticated animals and birds suffer from insect attack and parasites. Lice, bots, horse and stable flies, fleas and the like, and many animal diseases are carried by insects and their allies the ticks. Here also the *Diptera* contribute the bulk of the dangerous and troublesome species, and to our horses, cattle and sheep the elimination of all flies would be as great a boon as to man himself.

Insects also live with man as messmates, preying on his stored products or acting as scavengers in his dwelling, and all the main orders are represented in this heading. They are further injurious by feeding upon the crops grown by him, the annual losses figuring up to enormous sums—estimated at $1,500,000,000 for the United States alone. All parts of the plants above and below ground, outside and inside are infested, and all kinds of plants are attacked.

Many insects have been introduced from foreign countries and some have profoundly influenced our agricultural methods. The San José Scale has revolutionized fruit culture in the eastern United States and, incidentally, has made more positions for entomologists and stimulated more interest in entomological work, than all other species combined:—in which respects it is not an unmitigated pest.

There is, however, another side to this shield and there are also insects directly and indirectly beneficial. Bee products are of great value, and silk products are enormously so. Some insects are used in medicine, a very few for food, and a few also in the arts.

The chief value to man, of insects, is as pollenizers to plants, and many plants are entirely dependent upon them for their continued existence. Pollenizers are found among the *Coleoptera*, *Lepidoptera*, *Diptera*, and, pre-eminently, the *Hymenoptera*.

Portraits were shown, and brief notes were given of Say, Melsheimer, Haldeman, LeConte, Horn, Abbot, Morris, Grote, W. H. and Henry Edwards, Hulst, Strecker, Clemens, Hagen, Osten-Sacken, Loew, Ashmead, Packard, Scudder, Harris, Glover, Fitch, Walsh, LeBaron, Riley, Lintner and Fletcher. A few collectors and founders of early societies were also referred to, Akhurst and Schaupp of Brooklyn, the latter one of the founders of the Brooklyn Entomological Society, and Feldman, of Philadelphia, ancestor of three generations of Coleopterists—the Wenzels—after whom the Feldman Social was named. Pictures of field

meetings of the New York, Brooklyn, Newark and Philadelphia Societies in New Jersey were also shown and the address thus summarized.

" * * * insects are a factor of very great importance in the community, first, because of their injuries, direct and indirect; second, because of their benefits, also direct and indirect, and millions of dollars annually are involved on both sides of the ledger."

"The entomologist who studies these insects, determines which are harmful and which are beneficial, who works out their life histories and habits and who determines methods of controlling those that are harmful and improving those that are beneficial, is a worker of high importance to the community and deserving of every possible aid and assistance.'

A PREDACEOUS AND SUPPOSEDLY BENEFICIAL MITE, PEDICULOIDES, BECOMES NOXIOUS TO MAN.

By F. M. Webster,
Bureau of Entomology, Washington, D. C.

Introduction.

Attacks of mites upon humans are by no means new, various instances of this character having been observed in Europe and recorded in various English and Continental publications both entomological and medical. In this country, up to very recently, except in the case of the itch mite, *Sarcoptides psoriques* Megn., these have all been grouped under the name "chigger," which is evidently a corruption of "chigoe," a tropical species, *Sarcopsylla penetrans* L., which is not a mite at all, but a flea. Thus it has come about that people walking during summer in grassy or weedy places or in woodlands are very often attacked by "chiggers" and suffer serious inconvenience and much pain on account of attacks of what are probably the larvae of several species of mites; notably the Trombidiums, just which one or how many is not at present known.

The mite involved in the two epidemics of dermatitis in the United States, to which this paper especially relates, is quite certainly the same as the one discovered by myself in 1882 and determined for me by Mons. Jules Lichtenstein of Montpellier, France, as *Heteropus ventricosus*, Plate III, figs. 1, 3, and since known in this country as *Pediculoides ventricosus* Newport. Huber has since made this species a synonym of *Pediculoides tritici* Lagreze-Fossat, to which Moniez credits a large number of instances of mites attacking man in Europe.

MITES ATTACKING MAN IN EUROPE AND OTHER COUNTRIES.

In a publication relating to parasitology, both animal and vegetable, by R. Moniez,[1] quite a number of recorded instances have been brought together, some of them it is quite probable, involving the species to which this paper relates. Moniez is, however, vague and indefinite, and while crediting a large number of attacks of mites upon man to *Pediculoides tritici*, the fol-

1. Traite de Parasitologi Animale et Vegetal, Applique a la Medicine, Paris, 1896.

lowing statements made by him will most assuredly not apply to our American species, *P. ventricosus*, and if these food habits exist in *P. tritici*, this fact alone would separate the two species. On page 463 Moniez makes these statements:

"It appears certain that the octopod nymphs can only undergo evolution if they have at their disposition a liquid nourishment; they must attach themselves either upon some vegetable, or, in default of this, on some animal. In the case of wheat, they develop upon the larvae of insects that live at the expense of the grain. When the nymphs are famished, they will throw themselves upon workmen carrying wheat and attack the skin.

"Amerling, in Bohemia, did not find the mites in company with parasitic insects; they can live on the grain.

"When the cereals become dry, the mites attack animal life. They are forced to quit the vegetable kingdom for the animal. In this respect they act as do the Ixodes."

From the foregoing one is led to suspect that the obscurities surrounding the identity of man-attacking mites is scarcely less dense in Europe than it is in this country.

According to the observations of Lagreze[2] in 1849, in Espalais, France, a number of men engaged in carrying sacks of wheat experienced violent itching immediately thereafter. This wheat was sent to Bordeaux and Moissac where workmen in unloading the cargo were attacked in apparently the same manner. In the latter instance the men refused to work on account of the severe itching which immediately developed on the chest, arms, face and shoulders. In the case of a majority of the workmen this irritation of the skin was followed by an eruption of pimples more or less inflamed, some of which contained a serum. Later, experts who examined this grain reported the presence of numerous mites in the wheat and after this had been washed and dried in the sun, the workmen who handled it were not affected. The mite involved in this trouble is now known as *Pediculoides tritici*.

In 1867, Robin[3], in the name of M. Rouyer, communicated to the Society of Biology some observations on a cutaneous disease observed epidemically in a large number of communities of the department l'Indre. The peasants engaged in gathering the

2. (Lagreze Fossat et Montane, "Sur, la Mite du Ble." Rec. Agronomique de la So. de sciences agric. et belleslettres de Tarnet–Garome, t. XXXII, 1851).

3. Robin, C. R. des seances at memoires de la Soc. de biologie, 4th series, t. IV, 1867, page 178.)

wheat after the long rains of summer, developed an itching eruption on all exposed parts of the body.

May 1, 1872, a baker in the canton of Créon received a number of sacks of wheat from Bordeaux. Five men who were engaged in carrying these sacks promptly developed severe itching on the back, shoulders and arms, followed by an eruption of somewhat pointed red pimples. Fear seized the patients and their families, who thought themselves poisoned, but experts examining this wheat determined the cause of the trouble to be what is now known as *Pediculoides tritici*. The condition caused by this mite has been given the name of "grain fever."

In 1875, Targioni-Tozzetti[4] reported an eruption produced in a laborer who had carried sacks of wheat.

In 1879, Geber[5] observed in Lower Hungary an eruptive epidemic coming from barley. It appears that in the first days of the month of June, barley which was shipped from Lower Hungary, in sacks, was being unloaded at a railway station. After being engaged in this work for a few minutes, these laborers were attacked by a violent itching and burning and to such a degree did this become annoying and painful that it was with great difficulty that they were induced to continue their work. Geber desiring to obtain farther information, visited the railway station in question about ten days after and examined the laborers who had been attacked.

In order to carry out an experiment of his own, Geber employed an idiot to carry a sack of barley precisely as the laborers had done. The idiot also began unconsciously to scratch and immediately an eruption somewhat like nettle rash attacked him. It was observed at the time the laborers were handling these sacks of barley a yellowish-brown powder of considerable quantity fell out of the sacks and this circumstance turned the attention of the officials to the barley. Upon a small part of this powder being brought under a microscope the presence of both living and dead mites was revealed.

The illustrations of Geber's paper are two figures, figure 2 representing with reasonable accuracy what might have been a

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4. Targioni-Tozzetti, Relazione intorno ai lavori della Statione di Entomologie agraria di Firenze per l'anno, 1876, Annali, dell Agricultura, t. I, 1878.

5. Geber, Entzundliche Prozesse der Haut, durch eine bis jetzt. nicht bestimmute Milbe Varursacht; Wiener Med. Presse, Vol. 20, 1879, et V. Ziemssen's Handbunchd, spec. Pathol. u Therapie, t. XIV, Handbuch, d. Hautkrank, 2, 1884, page 412.

female of *Pediculoides ventricosus*, at a stage of her development when these mites are most abundant in grain and straw, that is to say they had not yet commenced to become gravid. After making drawings of the ventral surface, Geber instead of turning this same individual over and making a drawing of the reverse or dorsal side took for this purpose what he presumed to be another mite of the same species. The facts are that in all probability the second mite was a male, as in speaking of the striking agreement between the two individuals, he says "it remains to be noted only that the individuals shown by figure 2 were very rare, only here and there were they to be found and they were easily recognized by their peculiar form." In view of this it would seem quite probable that the mite involved in the eruption recorded by him might have been what we in America know as *Pediculoides ventricosus.*

In July 1882, Koller[6] records a case where 36 workmen in Budapest were engaged in unloading sacks of barley coming from Roumania and were seized within a half hour by an intense itching, increasing in intensity during the several succeeding days. Vesicles, the largest of which were the size of a millet seed, appeared on inflamed bases on the neck, chest and other portions of the bodies of these laborers. Koller states in this connection that several years previously he had observed a similar malady contracted after unloading sacks of wheat from a boat.

Prof. Howath found a mite in the wheat which completely resembled that described by Robin, and several years prior to this, similar observations had been made on the banks of the Theiss, and in this case there was no other way to avoid the trouble except to submerge the boat with its cargo. At the same time that Koller observed this case, trouble was observed at Cologne with wheat coming from Russia.

Flemming[7] in 1884 published the results of similar observations upon workmen in Klausenburg, who unloaded wheat imported from Russia and were suddenly seized with a skin eruption.

If we compare these records from different parts of Europe and involving other adjacent countries as well, we will notice the similarity between these epidemics of a dermatitis and those

6. Koller, G. Ein Getreide-Milbe als Krankheitserregerin. Analysed in Biolog. Centralbi, t. III, 1884, page 127.
7. Flemming, J. Ueber eine Geschlechtsreife Form der ala Tarsonemus beschrieben Thiere, Zeitschr. f. Naturwissensch B. LVII, 1884, page 472, pl. 2.

occurring in America as recorded in the following pages. It would however, be too much to say that in all of these cases *Pediculoides ventricosus* was the species involved; but in view of the fact that the Angoumois grain moth, *Sitotroga cerealella*, Plate III, fig. 2, frequently becomes even more of a grain pest in those countries than it does here in America, one cannot but suspect that either the same or a closely allied species of mite is responsible for these attacks upon man. Mr. W. D. Hunter tells me that in Mexico he was warned not to allow the mites to get upon the hands of himself or his associates in his attempts to artificially introduce them into cotton fields attacked by the weevil, thus showing that its effect on man was not unknown there. Quite recently the writer has been informed that precisely similar effects have been experienced in New York City by men in handling peas from Italy, infested by *Bruchus* larvae, on which *Pediculoides* were observed to be parasitic.

Pediculoides ventricosus was described in 1853, and *P. tritici* Lag.–Fos was described in 1851. Huber[8] has made the former species a synonym of the latter, which, if sustained would throw nearly or quite all of the epidemics of dermatitis recorded to the credit of the one species and this would be known as *Pediculoides tritici* Lagreze–Fossat.

In Zur Morphologie und Ontogenie der Acariden[9], Dr. Enzio Reuter cites *P. ventricosus* as a good species but makes no mention of *P. tritici*.

The Mite Beneficial in America.

So far as I have been able to determine, the first published record of the occurrence of this mite in America was by myself, and was included in a paper printed in the Twelfth Report of the State Entomologist of Illinois, for the year 1882, pages 150–151. While assistant to State Entomologist Dr. S. A. Forbes, I was directed to investigate serious injuries to stored grain by the Angoumois grain moth (*Sitotroga cerealella*) in southern Illinois, where Messrs. Halliday Bros., of Cairo, extensive growers and shippers of wheat, were at that time experiencing considerable trouble from the ravages of this grain moth, not only in their grain elevators but also, in barges loaded with wheat to be shipped by river to New Orleans and thence exported by steamer.

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8. Bibliographie der klinischen Entomologie (Hexapoden, Acaerinan.) von Med-Rath Dr. J. Ch. Huber, Jena, 1899.

9. Acta Societatis Scientiarum Fennicae. Tom. XXXVI, No. 4, pp. 185 and 195, 1909.

It was while making these investigations, that this mite was discovered attacking the larvae of the grain moth. As the original publication containing my observations is becoming more and more difficult to obtain, that portion of my paper relating to the occurrence of this mite is given herewith in full.

Pediculoides (Heteropus) ventricosus, Newport. About the 12th of October, 1882, a sack of wheat infested with larvae of the grain moth was received from Southern Illinois, which, for want of time, was put aside for future inspection. On the 13th of November, while examining the grains containing larvae, I noticed in a lot of fifty, three in which the worms were dead, and on them were numbers of globular, yellow objects, which proved to be a species of mite *Pediculoides (Heteropus) ventricosus*, Newport. Knowing nothing of the predaceous habits of these mites, and the limited literature at hand throwing little light upon the matter, I did not pay much attention to the fact of their occurrence, until the 12th of December, when upon examining one hundred grains with respect to the effect of heat on the larva, I found fourteen of the latter infested by these mites.

In the meantime I had learned that this mite was known to be of predaceous habit, in both England and France, (having been first discovered by Newport, in 1849, in the nests of *Anthophora retusa*, collected at Gravesend, England,) and afterwards described by him under its present name. It had also been found in France, in 1868, by Jules Lichtenstein, of Montpelier, and described by him under the name of *Physogaster larvarum*. This gentleman found it in his breeding cages, which it so completely overran that, as he informs me, he could not for six months breed a single specimen of Hymenoptera, of Buprestidae, or Cerambycidae, or of some Lepidoptera. If it has been found by any other persons than these, or in any other parts of the world, previous to its discovery here by me, I have not been able to find the fact recorded.

On December 31st and January 1st, I examined one hundred infested grains of this wheat, which had been continually kept in the laboratory since it was received, and found thirty-two per cent. of the worms dead, infested by the mites.

While making these examinations I frequently threw the grains containing infested larvae into a shallow glass dish, where they remained on my table until the warm weather during the latter part of February, when the temperature of the laboratory at night was much higher than it had been during the previous cold weather. The effect of the change was soon plainly to be seen. The contents of the dish began to swarm with newly developed mites, and a larva dropped into their midst was immediately attacked, and after that its life was of short duration. Larvae placed at some distance from the dish suffered a like infection.

To test the matter I placed near the dish some weeds, in the pith of which some larvae were hibernating, and in two days the mites had found and destroyed them. These young mites when first noticed are

very minute, of elongate form, and extremely active, running about in search of larvae; and when one is found they immediately puncture the skin and suck the juices.

In a day or two the posterior segments of the abdomen begin to enlarge and this process continues until the inflated, bladder-like abdomen becomes ten or even twenty times the size of the cephalothorax. Plate III, Fig. 3.

During this time they have gradually lost their ambulatory powers, and remain stationary upon their victims. In the meantime changes equally wonderful have been going on within the abdomen.

Eggs are continually forming, and within these the young mites are as continually developing, passing through their entire metamorphosis, *which includes the acquisition of the fourth pair of legs,* (an exceptional character among mites) within the abdomen of the mother, from which they make their way as fast as they reach maturity.

The females are quite prolific. I have counted frequently from forty to fifty young and eggs within the abdomen, and believe that they produce even more. The mothers survive the birth of a large number, if not a majority of the young. The male I have never found, and I am inclined to believe with Mr. Newport, that the species is parthenogenous.[10] The minute size of those young mites admits of their free access to the larvae of the moth, through the very small opening where this made its entry, and a single mite with its progeny would be sufficient to destroy it.

That this is very often the manner of attack is proved by the fact that grains in which the larvae is badly infested frequently have no other break in the hull by which even a young mite could gain admission. Like the larvae on which they subsist, their development is retarded or increased by the temperature, they being quite active at a temperature of 60° Fah.; but in colder weather able to remain within the abdomen of the parent for months in a dormant state, awaiting a rising temperature.

While, as stated, this was probably the first published record of the occurrence of this *Pediculoides* in America, I have since had reason to believe that it was present many years prior to this date, and, indeed, in the light of information that has been obtained during the present year, 1909, it seems altogether probable that it not only occurred but became noxious to man, in Massachusetts, as early as 1830.

The particular reference, however, to which attention is called may be found in the "Prairie Farmer" for the year 1845, page 216. Much is here made of larvae attacking the stems of wheat above the upper joint and in connection therewith follows this significant sentence: "In one instance nine eggs were found in a

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10. I have since observed the male though only occasionally, as it is probable that each ♀ produces but one ♂ among her numerous progeny.

single straw, one of which had just hatched." Also, in another journal, we are told that specimens of infested straw were forwarded to the "Country Gentleman" from Scipioville, New York in 1879, which the sender stated contained eggs besides larvae and pupae. In both cases, the larvae were almost beyond a doubt those of *Meromyza americana*. According to my own observation, these mites attack the larvae of *Meromyza americana* in stems of wheat, and, when observed, one cannot fail to be struck with the clearness with which the statements just given describe larvae of this species in the stem of grain or grass being attacked by these mites, the gravid ♀ of which has every appearance to the unaided eye of being a minute egg. It therefore seems not improbable that this *Pediculoides* was abroad over the country at the earlier date, 1845, which would antedate by several years the description of the species by Newport in England; who called attention to the occurrence of this mite as a parasite in the nests of *Anthophora retusa*, in a paper read March 5, 1850, before the Linnean Society of London, and with the description published in the transactions of this Society, Volume XXI, 2, p. 95, 1853.

In the account given by Dr. T. W. Harris in the second edition of his "Insects Injurious to Vegetation" in connection with his discussion of the early occurrences of the barley Isosoma, *Isosoma hordei*, there are two very significant statements that have until lately puzzled me very greatly. On page 438, edition of 1852, he states that "in the summer of 1831, myriads of these flies (meaning the adult *Isosoma*) were found alive in straw beds in Gloucester; the straw having been taken from the fields the year before. An opinion at that time prevailed, that the troublesome humors, wherewith many persons were then afflicted, were occasioned by the bites of these flies; and it is stated that the straw beds of Lexington, being found to be infested with the same insects, were generally burnt." The second reference occurs on page 440 of the same volume, in which it is stated that "about eight years ago (which would be about 1844) some of these insects (again referring to *I. hordei*) that had come from a straw bed in Cambridge were shown to me. They had proven very troublesome to children sleeping on the bed; their bites or stings being followed by considerable inflammation and irritation, which lasted several days. So numerous were the insects that it was found necessary to empty the bed-tick and burn the straw."

Now, since first beginning the study of *Isosoma*, it has always been a puzzle to me, why it was that the adults of *Isosoma hordei*, as they were described by Dr. Harris, should have been able to bite through bed-ticking and cause the eruption described, and yet not be able to gnaw through this cloth and make their escape, as every one who has reared these insects in confinement has witnessed their frantic efforts to escape as soon as they gnaw their way out of the straw. It seems to me that, in this mite, now, we have as good an explanation as we can expect to secure, after a lapse of three-quarters of a century, with no possibility of obtaining actual proof in the case.

In 1884, I found this same mite attacking and destroying the larvae of *Isosoma grande* at Oxford, Indiana, and in speaking of the occurrence of this larva and its parasites, I made this statement: "Curiously enough, during the time it occupies the stubble in the larval and pupal stages, it sometimes falls a victim to the mite *Pediculoides* (*Heteropus*) *ventricosus*, which enters the stubble from above after the grain is cut, but whose sense of discrimination is rather poorly developed, and it is finally victorious over the *Isosoma* larvae, its parasites, and the predaceous larvae of *Leptotrachelus dorsalis*." The same year, and in the same locality, I again encountered this mite attacking the larvae of *Meromyza americana* in wheat straw, and again noted the remarkable resemblance of the gravid females to minute eggs. Since that time, this *Pediculoides* has been reported by Mr. E. H. Ehrhorn attacking the larvae of the peach twig borer, *Anarsia lineatella* Zeller, in California.[11] The same year Mr. Marlatt reports it as attacking the eggs of the periodical cicada *Cicada septemdecim*.[12] Still later, in 1904, Messrs. W. D. Hunter and W. E. Hinds in Bulletin No. 45, Division of Entomology, page 107, called attention to its attack on the larvae of the cotton boll weevil. In 1908, Mr. W. Dwight Pierce, in Bulletin No. 73, Bureau of Entomology, page 30, states that this mite is a common weevil parasite in Mexico. In the same publication, page 42, he accredits it to being parasitic not only on the cotton boll weevil, *Anthonomus grandis*, but also on an allied species, *A. eugenii*. Dr. A. D. Hopkins informs me that in his studies of forest insects, he has encountered it attacking the larvae of wood boring beetles and at

11. Bulletin No. 10, U. S. Dept. of Agriculture, Div. of Entomology, p. 17, 1898.

12. Bulletin No. 14, Div. of Entomology, n. s. p. 104.

one time, in West Virginia, it caused considerable mortality in his breeding cages, where he was attempting to rear wood-boring Cerambycidae and Scolytidae, precisely as experienced, in France, by M. Jules Lichtenstien.

Mr. W. J. Phillips observed this mite attacking the larvæ of *Mordellistina ustulata*, in Indiana, October 3, 1905, while investigating the occurrence of these larvae in the stems of timothy and other grasses.

In the publication of Messrs. Hunter and Hinds, previously referred to, some information is given relative to the attempt to use this mite artificially in overcoming the boll weevil. It has been experimented with quite extensively by Prof. A. L. Herrera and his assistants of the Mexican Commission of Parasitology, and upon his return from a trip to Mexico in the fall of 1902, Mr. Hunter brought with him, through the kindness of Prof. Herrera, a supply of the parasites, from which others were reared for experimental work in Texas. This experiment, however, owing to conditions beyond the control of man, perhaps happily so, appears not to have resulted satisfactorily. One of the principal obstacles in this case seems to have been that, where the mites succeeded in establishing themselves, they were subsequently destroyed by the attacks of small ants.

These references show quite clearly the wide distribution of this mite throughout the United States and its great variety of host insects. We have, in later years, come to consider it a very useful parasite and one that is likely to attack almost any soft-bodied larvae, beyond the reach of insecticides, but to which it, by reason of its minute size, could gain access and be secure from other predaceous insects and adverse meteorological conditions.

The Mite Becomes Noxious to Man.

While, as stated in the earlier portion of this paper, either this or some other closely allied species has long been known to occasionally attack man and animals in Europe, when these are engaged in handling or come into contact with grain or straw infested by their host insects, the first instance of this character to be noted in America has been communicated to me by the present presiding officer of this Society, Dr. Henry Skinner, of Philadelphia, Pa. It was about the year, 1894 while Dr. Skinner was practicing medicine in Philadelphia, that the owner of a boarding house in one of the New Jersey suburbs of the city came

to him in great distress, stating that the tenant and keeper of the boarding house, which accommodated about seventy-five persons, would not pay the rent thereon, and further stated that the tenant had been threatened with legal proceedings by the boarders who had even suggested bodily injury. The cause of all of this trouble was an epidemic of a rash like disease, the causes of which were suspected to lie in the mattresses of the beds occupied by the patrons of the house, because of the occupants having been attacked by a very mysterious and aggravating skin eruption. The owner submitted straw dust and mattress debris taken from the suspected beds and on examination of this Dr. Skinner found specimens of this mite. The house was promptly deserted by the boarders, none of whom as it seems escaped infection and none of whom were willing to return. The matter does not appear to have been further investigated.

In the Philadelphia Medical Journal for July 6, 1901, Jay F. Schamberg, M. D., of Philadelphia, published a short paper, calling attention to and describing "An Epidemic of a Peculiar and Unfamiliar Disease of the Skin." In this paper, Dr. Schamberg, who, besides being a practicing physician, is professor of Dermatology, and Infectious Eruptive Diseases, in the Philadelphia Polyclinic, described a number of cases that had been treated by him a few weeks prior to the publication of this paper. The eruption and its effect on the patient were briefly described and illustrated, but the causes instrumental in bringing about these attacks were still unknown to him; and as several members of the same household were commonly affected the disease was considered likely to prove contagious. The dermatitis, however, was not lost sight of, and in a paper contributed to the Public Health Reports, Volume XXIV, No. 28, July 9, 1909, Dr. Joseph Goldberger, Past Assistant Surgeon of the United States Public Health and Marine Hospital Service, in cooperation with Dr. Schamberg, published the first exact information we have relative to the cause of these epidemics and this paper, so far as known to me, is the first publication in this country in which the attack of this mite has been followed up and its dermatological effect on humans carefully studied and described. This paper of Drs. Goldberger and Schamberg may be briefly summarized as follows:

In the spring and summer of 1909, this peculiar eruptive disease became quite prevalent in Philadelphia and neighboring

towns. An outbreak among 20 sailors upon a private yacht docked in the Delaware River attracted the attention of both the city and the Federal Health Authorities. The Surgeon-General of the U. S. Public Health and Marine Hospital Service delegated Dr. Joseph Goldberger, Passed Assistant Surgeon, to proceed to Philadelphia in order to make an investigation of the disease.

After examining the 20 sailors who had been sent to a hospital, Drs. Goldberger and Schamberg visited the yacht whence they came and made a searching examination of the conditions on board. Their attention was directed to the fact that a number of new straw mattresses had been received and that the disease was confined to those who had slept upon these mattresses or had placed their clothes upon them. Eleven officers and members of the crew who did not sleep upon the new mattresses remained entirely free of the disease.

At about the same period information was received concerning an eruptive disease prevailing among the sailors of four other boats, plying along the Delaware River. Investigation disclosed the fact that these boats had also received new straw mattresses, and, furthermore, that only those were attacked who slept upon the mattresses or otherwise came in contact with them.

In addition to these cases among sailors, Doctors Goldberger and Schamberg examined or received authentic information concerning 70 other cases of this disease occurring in twenty different households in Philadelphia and its vicinity. Plate IV.

In practically every instance they were enabled to determine that the patient had either recently slept upon a new straw mattress or had freely handled the same. Where only one person in a household was affected, it was found that he was the only one to occupy a bed supplied with a new straw mattress. They were able to trace all of the incriminated mattresses to four leading mattress manufacturers.

Careful investigation warranted them in excluding from consideration the ticking of the mattresses and the jute or cotton topping contained therein. The cause of the disease was, therefore, circumscribed to the straw. Repeated inquiries elicited the information that all of the manufacturers had received at the time the disease-producing mattresses were made up, wheat-straw from a dealer in Salem County, in southern New Jersey.

One manufacturer had used straw from this source exclusively in the affected mattresses.

Finding of a Parasite. Drs. Goldberger and Schamberg sifted the straw from a mattress through the meshes of a fine flour sieve upon a large plate glass covered with white paper. Close scrutiny of the siftings under strong electric illumination soon detected some slight motion. The moving particles were touched with a needle moistened in glycerine and transferred to a glass slide. Search with the microscope disclosed the presence of a mite of very minute dimensions. The mite was identified for them by Mr. Nathan Banks, expert in Acarina of the U. S. Bureau of Entomology, as very close to, if not identical with, the *Pediculoides ventricosus.*

In order to demonstrate experimentally the ethiological relationship of the suspected straw mattresses, Dr. Goldberger exposed his bared left arm and shoulder for one hour between two mattresses. At the end of about 16 hours, a number of characteristic lesions appeared upon the arm, shoulder and chest. Later three volunteers slept upon the mattresses and each one developed the eruption at the end of about the same period.

Dr. Goldberger later took some of the sifted straw, divided it into two portions and placed it in two clean Petri glass dishes. One of these was applied for one hour to the left axilla of a volunteer. At the end of from 16 to 17 hours, the characteristic eruption was present in the area of the left axilla to which the Petri dish of straw siftings had been applied.

The second portion of the straw siftings in a Petri dish was exposed to the vapor of chloroform under a bell jar with a view to killing any insect or acarine that might be present. These siftings were then applied to the right axilla of the same volunteer to whose left axilla the untreated siftings had been applied. The chloroform evidently destroyed in the siftings the agent that was producing the eruption for no lesions appeared after the application of the chloroformized siftings.

Dr. Goldberger further fished out of some straw siftings five minute mites, and, placing them in a clean watch crystal, applied the crystal to the axilla of another volunteer. At the end of about 16 hours following this application, five of the characteristic lesions appeared on the area to which the mites had been applied. Plate V, fig. 1.

Influences Controlling the Excessive Abundance of Pediculoides.

It will be noticed that Drs. Goldberger and Schamberg made no attempt to discover the underlying causes for the enormous numbers of these mites inhabiting the mattresses involved in their investigations, that problem belonging more properly within the realm of the entomologist. On my taking up this subject of the excessive abundance of the mites, Drs. Goldberger and Schamberg very kindly placed at my disposal everything in their possession relating to this epidemic, including the mattress which Dr. Goldberger had himself used in experiments carried out by him at the hygienic laboratory in Washington with this mite. Dr. Schamberg was equally kind in placing all of the material, notes and photographs in his possession, at my service.

Almost at the commencement of the investigation, Dr. Wm. Royal Stokes of the Maryland State Board of Health informed me that a similar but less extensive epidemic had shortly before been noted in Baltimore, This he kindly described as follows:

"The matter was brought to my attention by several persons who came to the Head of the Department and complained of the skin eruption described. They stated that a number of people in a suburban hotel were similarly affected, but I do not remember the number at this late date. These persons volunteered the information that they had all been sleeping on some new straw mattresses, and that all of the persons similarly affected had used these mattresses.

"I saw Dr. Gilchrist, the Clinical Professor of Dermatology at Johns Hopkins University, yesterday, and he gave me the following description of the one case which he saw at the Health Department. I saw two other cases which corresponded with these in a general way.

" 'The eruption consisted of about 1000 wheals, or erythemato-withicarial spots, or pauplo-withicarial lesions. As in the description in the reprint of Drs. Goldberger and Schamberg of the United States Public Health and Marine Hospital Service, they varied in size from a lentil seed to a finger nail, and are round, oval, or irregular in shape. No vesicles or pustules were seen. The eruption was on the neck, chest, abdomen, and back, and also on arms and legs. Itching was present, and all lesions showed evidences of scratching.' "

Besides this, there were several cases reported to me from northern Maryland, where farmers in running their wheat through a fanning mill had been simultaneously troubled by a very similar or identical eruptive disease of the skin. In another instance, a thresherman engaged in feeding the unthreshed grain into the cylinder of the threshing machine was also affected by a disease of the skin, with which the attending physician was unfamiliar and who could not classify it with any of the urticaroid dermatitis known to him. With my experience of previous years, it seemed impossible that this *Pediculoides* should become sufficiently abundant to cause this dermatitis without there being an excessive abundance of some host insect or insects affecting either the straw or the grain itself. Naturally, the studies made by me in 1882, led me to suspect that this grain moth *Sitotroga cerealella* might be responsible for the abundance of the mites. Then, too, the fact that it attacked the larvae of *Isosoma grande* in wheat straw, led me to suspect that, as this particular species is not known to occur in the vicinity of Philadelphia, while its near relative, the joint worm, *Isosoma tritici*, does occur more or less abundantly over the eastern part of the country, this latter species, too, might perhaps be involved.

With a view of finding out something of the abundance of the grain moth in New Jersey, from which State was obtained most but not all of the straw entering into the mattresses mentioned by Drs. Goldberger and Schamberg, I applied to Dr. John B. Smith, State Entomologist, for information. In reply Dr. Smith was kind enough to send me an advance copy of the report of his department of the New Jersey Agricultural Experiment Station for the year 1908, and from this publication it was learned that during the summer of that year, owing to favorable weather conditions, this moth developed rapidly in the field and there was great damage to wheat among those farmers who delayed threshing until September or later. Furthermore, a very large percentage of the wheat crop gathered that year became useless for milling purposes and so general was the infestation that grain from some localities was entirely barred at mills except when ground for the owner. Some further investigations carried on in eastern Pennsylvania revealed a very similar condition of affairs. It was the straw of 1908, coming mostly from New Jersey, but a small part of it from Indiana, that en-

tered into the mattresses, from the use of which came the epidemic in and about Philadelphia.

In order to settle these points, Mr. V. L. Wildermuth, an assistant in the Bureau of Entomology, in cereal and forage insect investigations, was instructed to examine the straw in the mattress placed at my disposal by Dr. Goldberger. After a day and a half of careful search, only five straws affected by the joint worm were found. This seemed to entirely eliminate this species from consideration in connection with this particular epidemic. There were, however, many wheat heads remaining attached to the straw-and these heads contained a great many kernels, the contents of which had been eaten out by the larvae of the grain moth. Morever, these eaten kernels contained great numbers of the dead bodies of Pediculoides. That *Sitotroga cerealella* was the cause of this damage to the wheat was still further proven by the emergence of an adult moth from these eaten kernels on November 15. The larvae of this moth infested the kernels of wheat before the latter were threshed. Many of these infested kernels remaining in the straw were included in the material going into the manufacture of these mattresses. The greater portion of the living larvae of the moth would develop to adults during May or early June, thus cutting off the food supply of these mites. The mites would therefore very naturally swarm among the straw and making their way through the cloth covering of these mattresses attack anything that gave promise of furnishing food, and preserving them from starvation. It seems that starvation is the final outcome, however, for, as already stated, no trouble is experienced in using the mattresses after a certain period, which period probably indicates the termination of the life of the mites infesting the straw. It therefore did not seem necessary to seek farther for the primary cause of this eastern epidemic of dermatitis, the center of which seems to have been in and about Philadelphia.

A Western Epidemic of the Dermatitis.

While the problem of the epidemic in the east was apparently solved, some of the wheat straw involved therein had come from Indiana, and during the last few years an outbreak of the joint worm, *Isosoma tritici*, had been gathering force, throughout Ohio, Indiana and southern Illinois, until during the summer of 1908, very serious damages occurred. Investigation of the insect dur-

ing previous years had shown that the outbreak really began in the more elevated portions of Virginia, in the upper Shenandoah Valley, West Virginia and eastern Ohio, as early as 1904; afterwards advancing broadly to the westward.

During the summer of 1908, there came to the Bureau, from this section of the country, a great number of complaints of serious skin trouble among people engaged in threshing grain that had been stored for some time in barns; in some localities it having become difficult to secure help to thresh under such conditions. Also the same disorder was encountered by those who used this straw for the purpose of filling bed-ticks, or as a substitute for felting under carpets, and in one case, berry pickers had been attacked when such straw had been used as a mulch for berry plants. This straw came from one of the fields most seriously injured by joint worm attacks in 1908. In one instance, a carload of wheat straw was shipped to Pittsburg, Pa., and six men engaged in unloading it, were all attacked by some skin eruption, and the horses used in hauling this straw after it was unloaded, also suffered from what was seemingly the same disorder. Perhaps the following from a correspondent of the Bureau of Entomology, residing in southern Ohio, will give a fair idea of the situation on many farms in that section of the country.

" About four years ago a parasite was found when threshing wheat out of barns. They seem to affect the victims almost as soon as they get into the mow. The men began to scratch themselves generally on the neck and on the arms (inside) opposite the elbow, and on the body back and front. They raised welts as you describe and progress about as you describe. They have spread to such an extent that farm hands dread and fear them and will not change work with neighbors unless they thresh in the field. (They are found out of barns.) Here of late they are found in wheat straw in the barns, especially if baled. Last week a farmer brought me baled wheat straw that seemed to be alive with them. They attacked every one that went in the barn and one of my horses that was perspiring from effects of a drive was simply covered with little knots or swollen places and bit and rubbed himself continually. I had to have the straw hauled out and burned and barn disinfected. The farmer stated that they were so thick in the shed that contained the straw, that he had to keep all stock out of the shed."

Many other similar letters from towns in Ohio were received by Dr. Schamberg, particularly from Zanesville, Columbus, Vincent, Springfield, etc., where the affection is popularly believed to be due to "chiggers." A physician from the last named town stated that in the fall of 1908, during harvest and threshing time he saw in Washington County some 87 cases of the disease in question. It affected the harvesters and threshers. This spring he observed 38 cases from contact with straw ticks refilled with straw of last fall's crop. The disease is said to have been more prevalent last year (1908) than ever before. Information has come from Columbus, Ohio, that potters who used straw for packing crockery ware have been so badly attacked at times that the entire force of packers has been off duty. Many times a whole car-load of straw has been so affected that the use of it has been abandoned. In Springfield, Ohio, it is said that the disease was so bad a year or two ago in the lowlands west of this city as seriously to hamper the progress of the construction of a large sewer. This, however, might have been due to attack by other mites, notably to Trombidium larvae. In Zanesville, Ohio, the potters have been obliged to abandon the use of straw and employ "prairie hay" for packing purposes.

Dr. Schamberg was also informed by a physician of Pittsburg that a young woman patient has suffered from an affection closely resembling, if not identical, with the one under consideration, each time that she has assisted in emptying cases of dishes packed in straw. Both the physician and the patient had come to believe that something in the straw was the cause of the eruption.

Indeed, so nearly did the territory from which these complaints came to us, coincide with that affected by the joint worm, that it created the suspicion, not only among those engaged in the investigations, but even among farmers themselves, that there must be some connection between the two phenomena. Very many of these cases were brought to the notice of practicing physicians, but they were themselves at a loss to account for the prevalence of this dermatitis, many of them supposing it to be some species of rash that was more or less contagious, the exact nature of which they did not know.

Among these physicians was Dr. Lyman T. Rawles, of Huntertown, Indiana, who in May, 1909, took up a careful study of a number of cases of this dermatitis that had come under his personal observation as well as those of some of his associates. Dr.

Rawles' investigations were very carefully made and the results are exceedingly valuable for the reason that, in case of this western epidemic, he was able to trace the cause of the dermatitis to *Pediculoides ventricosus* and follow this back to the host insect *Isosoma tritici*. This paper of Dr. Rawles[13], of which a summary is given, not only clears up the obscurity with reference to the cause of this epidemic in the Middle West, a section throughout which the grain moth (*Sitotroga cerealella*) never occurs in excessive abundance excepting in grain that is kept in store, and then only in the more southern portions of Indiana and Illinois; but, furthermore, these studies seem to solve the problem of the cause of the skin eruption noted by Dr. Harris to have occurred as far back as 1830.

In May, 1909, Dr. Rawles found in his practice that a very strikingly strange skin disease presented itself in his and surrounding country in epidemic form. Through the press notes it seemed to be quite general over the northern part of the United States, limiting itself to the wheat growing sections.

The people generally affected were farmers and those living in small villages or towns where straw is used in beds, under carpets and around stables to bed stock. Horses and cattle have been seen with a skin disease almost identical to that seen in man. The following incident led him to an investigation as to the probable etiology:

A family had cleaned house, refilling the straw ticks of their beds and placed fresh straw under the carpets, and in about one week the family had developed this peculiar skin disease. In the beds were found a small, black fly, *Isosoma tritici* Fitch, about the size of an ordinary gnat, which at first it appeared to be, but closer observation revealed that it was not of the gnat family. Upon examination of the straw it was found that a large number of the straws were perforated; these perforations were through the wall in the region of the joint, generally about two inches from the joint. The perforations were about the size of a small pinhole and ranging in number from ten to thirty in a straw. Upon examining a section of this straw the *small black fly* was found *under many* of the openings through the walls.

Several flies were examined to ascertain if they possessed a piercing proboscus, and while observing one which has just been taken from under the sheath of the straw, through which there

13. Journal of the Indiana State Medical Association, August, 1909.

was no perforation over the fly, a small mite was observed crawling over the dead body of the fly.

Placing the bodies of several of these flies under the microscope and using a ¼-inch objective and a No. 5 eye-piece, it was found that on nearly all flies over which the wall was intact, a small mite could be detected, these mites varying in number from two to four mites to each fly. Upon furthering the observations it was found that the dermatitis lasted after the flies had been observed and exterminated.

The following experiments were tried to prove whether it might be the fly or the mite that was the etiologic factor in producing the dermatitis.

Six live flies were taken, upon which no mites could be found; these were placed under a watch glass and bound upon the right arm, leaving them in contact with the skin for three hours. Upon the left arm four dead flies, on which living mites had been observed, were placed under a watch glass and left in contact with the skin for three hours, after which the glasses were removed and results awaited. The right arm showed nothing. Upon the left arm there appeared within twelve hours four small wheals, the character and evolution of which are later described.

To further the experiments some fresh lesions of patients were scraped and the scrapings examined microscopically and two of the mites were found in the scrapings.

Itching is the most prevalent and first symptom to attract the attention of the patient. It is most persistent and intense during the after part of the night. At about the time the itching was most intense there appeared an urticarial eruption, accompanied, in severe cases, with general systemic symptoms, such as rise of temperature from 99 to 102; in one case the temperature rose to 103.8; the pulse rate is accelerated to 100, or as high as 110—in one case to 130. Other symptoms were intense headache, anorexia, nausea, in some cases vomiting, and a mild form of diarrhoea. In severe cases some complained of general joint pains and backache; in these cases the urine was examined and albumin in small amount was found, but no casts or blood. When the acute symptoms disappeared so did the albumin.

Many patients who suffered from mild cases complained of nothing aside from the intense itching. If all straw was removed from the beds and house the symptoms would subside in one or two days and completely disappear in a few days more.

The lesion which is typical of the disease is the urticaria vesiculosa. The urticarial lesion varies in size from that of a split pea to that of a penny; it is surrounded by a pinkish halo, varying in intensity of color from a pale pink to a most bright pink. The "hive" like lesion is at first blanched, but later becomes a rose red color. It is elevated about 1 or 2 mm. above the skin surface, and is surmounted by a small vesicle containing a whitish fluid marking the place of inoculation. The vesicle is about 1 or 2 mm. in diameter and elevated about 3 mm. above the surface of the urticarial lesion. As the lesion grows old it goes through the process of evolution: (1) it is blanched and has a central vesicle; (2) it is rose red and the vesicle may become a pustule; (3) it generally recedes to the skin level with scab formation, due to the scratching; (4) it leaves a browinsh or greenish-yellow or purple spot on the skin surface. In debilitated patients the markings look not unlike faded indelible pencil marks. (This was noted in a patient suffering from pulmonary tuberculosis.) These discolorations may last for several weeks.

The anatomical location of the lesions is generally the back, sides and abdomen, and less frequently the arms and legs. The neck has very few lesions; the face, hands and feet have very few or none.

The number of lesions depends upon the number of mites, ranging in number from very few to thousands; in some cases the back and abdomen have been almost a solid mass of lesions—new lesions on the tops of old lesions, so having lesions in all stages of development.

Obscurity Surrounding the Occurrence of the Dermatitis.

The exact nature of this eruptive disease was not at all understood by the medical profession throughout the country. In South-western Virginia, threshermen suffered from the same disorder, but attributed it to "chiggers," and local physicians, though skeptical, were themselves unable to correctly diagnosis or to account for the trouble. As the disease is not serious and passes away in the course of time without leaving the patient in any way permanently injured, it seems to have been passed over by medical men without investigation excepting by the physicians whose publications have just been cited. Among the people themselves the eruption was probably more frequently attributed

to attacks of "chiggers" than to any other cause and it is quite likely that this common erroneous interpretation of the origin of the eruption has prevailed generally throughout the country, including the upper Shanandoah Valley in Virginia, where the joint worm was abundant as far back as 1904. It has been confused with small-pox and more frequently with chicken-pox. It, was, consequently, exceedingly unfortunate that, with the beginning of this disorder, an institution in one of the States involved, should publish an unsigned newspaper bulletin, crediting these epidemics of this eruption to the attack of "chiggers," and, furthermore, at the very time when Drs. Goldberger, Schamberg and Rawles, as well as the Bureau of Entomology, were exerting every effort to find out the true cause of the difficulty, that a second press bulletin, accentuating the first, should have been issued, and, sent to every newspaper in the State, and from those copied into other newspapers throughout the country. Thus it is that an entirely erroneous impression has been magnified and diffused, still continuing to prevail throughout the country.

In order to determine the likelihood of those handling straws in the wheat field, being attacked by the small red mites, often innocently mistaken for "chiggers," that abound among the harvested grain at this time, Mr. Wildermuth made a number of experiments to determine whether or not these mites, probably Tydius sp., were liable to attack men. In no case was he able to provoke an attack from them, even when they were confined upon the skin of his bare arm. On the other hand, examination of straws from various points in Ohio and Indiana have revealed the presence of *Pediculoides* in the cells occupied by the joint worm. This seems to entirely eliminate "chiggers" from these investigations, because these were probably not present, and there does not longer appear to be any doubt but what *Pediculoides ventricosus* is to be charged with causing these epidemics of this dermatitis, and the cause of its own excessive abundance lies in the outbreaks of the Angoumois grain moth among the grain itself in the East and the joint worm in the wheat straw in the Middle West.

Light Thrown Upon Other Problems.

These investigations have illustrated very nicely the extent to which the solution of one entomological problem will at the same time also solve other problems more or less closely allied to

the original one. The light thrown upon the cases of eruption noted by Dr. Harris with reference to *Isosoma hordei* has already been explained. The present outbreak of the joint worm in the Ohio Valley probably originated in the upper Shenandoah Valley of Virginia, extending northward and westward throughout West Virginia and eastern Ohio. When investigation of the insect was taken up in 1904, a parasite, *Ditropinotus aureoviridis*, was also noted in excessive abundance, but for some reason it did not overcome the joint worm. This phenomenon has been noted continually. Since that time it has been a perpetual enigma to me why it was that with such an abundance of its natural enemies the joint worm should continue to spread and increase in destructiveness. Now, however, that we know that this predaceous mite is able to develop through a series of years in such immense numbers in connection with the joint worm, the matter comes nearer a solution. *Ditropinotus*, as well as some other parasitic enemies of the joint worm, emerge in early July from eggs that were previously placed in the cells occupied by the joint worm. As soon as these adult parasites emerge they at once oviposit in cells containing joint worm larvae of the same generation from which they themselves developed. The puncturing of these cells by the ovipositor of these parasites, particularly *Ditropinotus*, opens a way for the entrance of this microscopic mite, and, once inside of the cell, it will destroy everything therein, whether it be joint worm or parasite. Thus the predaceous mite has prevented the other parasites from exerting their full influence, because it has continually checked the increase of other parasites, thereby preventing them from increasing and exerting the restraining influence upon the joint worm that, but for this mite, they probably would have done.

In the light of the foregoing, it would appear that the only way to evade this disorder among humans, caused by this mite, lies the prevention of the occurrence of these two destructive grain insects which are responsible for the abundance of the mite itself. There is, therefore, a double incentive for the farmer to use every effort to prevent the occurrence of these pests in his fields. In many fields in Ohio we have found that more than one-half of the straws had been attacked by joint worm, and the damage resulting from their attacks amounted to a considerable percentage of the farmers wheat crop. See Plate V, fig. 2. If, in addition to this, his own family and employees are to suffer

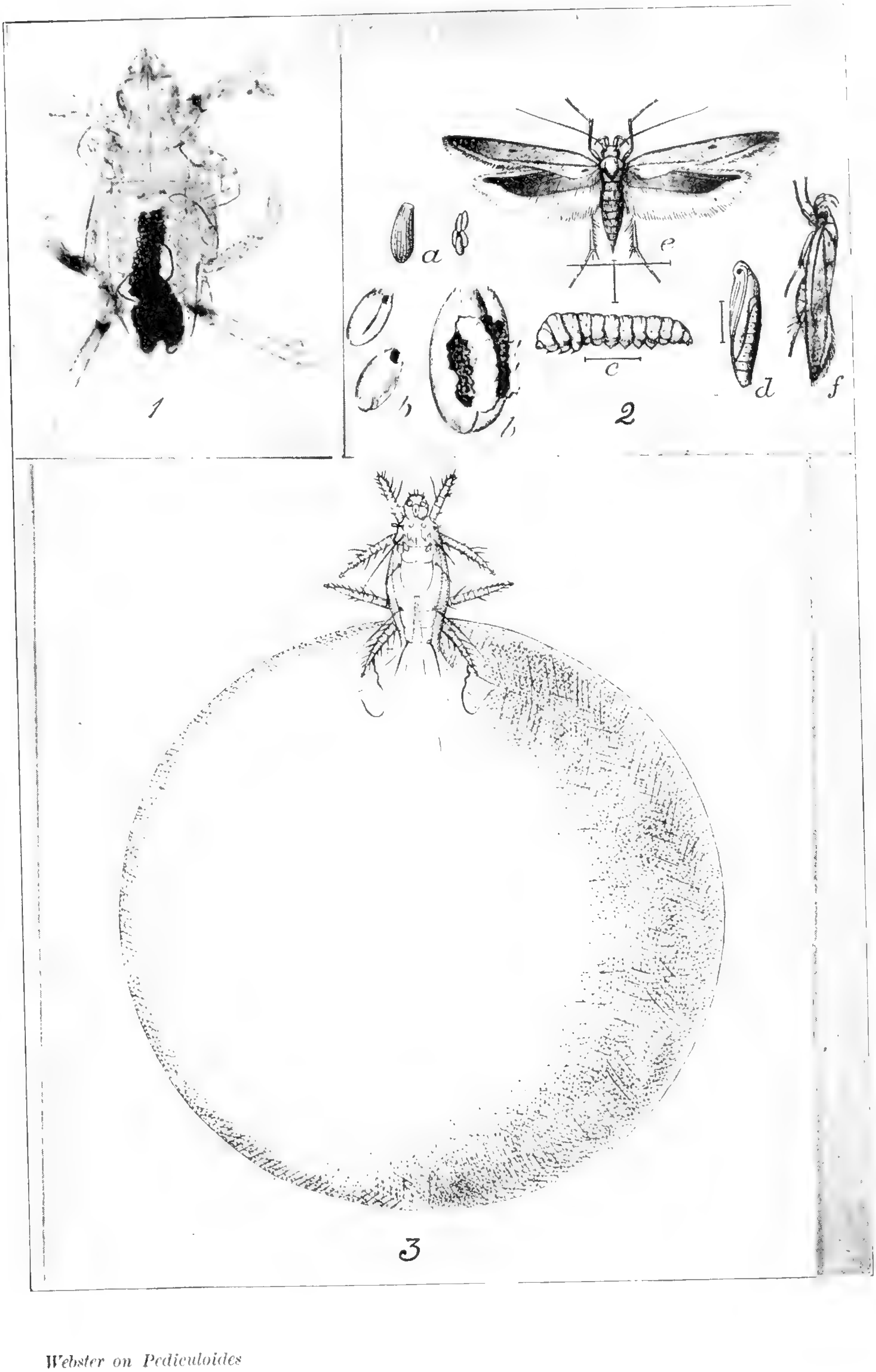
annoyance from this dermatitis, and we know that the mite is present generally, also those who attempt to use mattresses into the construction of which the straws from these fields have entered and indeed in even handling the same, the results of his agricultural methods will be sent wherever, in the entire country, these mattresses, or the straw itself, go into practical use within at least a year from the time the wheat straw was harvested in the fields, and thus people hundreds of miles away, with no possible means of knowing of the presence of these mites in mattresses, are caused not only great aggravation but intense suffering through their use.

Preventive and Protective Measures.

From the foregoing, it will be observed that that public protection from this skin disorder is only to be secured through revised agricultural methods of the farmer, who, while offering this protection, will also materially increase the profits of his business. Throughout the territory involved in the eastern epidemic of this dermatitis, which, as has been shown, was due to the excessive abundance of the Angoumois grain moth, the evidence recently attained by the writer has been overwhelmingly to the effect that where wheat was threshed as promptly as possible after harvest and directly from the shocks in the field, almost no occurrence of this grain moth was observed by millers and others handling the threshed grain, and without which there would have been no mites. On the other hand, when drawn from the field and placed unthreshed in the barn, the damage from this pest has varied up to nearly fifty per cent., and has so affected the crop as to cause its rejection by millers, except where ground on the farmer's order. Here, then, lies the protection of people who use mattresses made of this wheat straw, grown in this section of the country, or otherwise come in contact with the same. Reiterating in a condensed statement: Wheat should be threshed immediately after harvest and directly from the field.

In Ohio, Indiana and Illinois, where the mite causing this dermatitis has increased enormously on account of the prevalence of the joint worm, see Plate V, fig. 3, wheat also placed in barn before threshing has been found to be much more dangerous to handle with reference to epidemics of this disorder. At the same time, the difference between wheat threshed in the field and in the barn is not so striking as where the primary trouble was in the abundance of the grain moth.

A careful study of a large number of wheat fields in central Ohio, has shown that the infestation from joint worm, the present



Webster on Pediculoides

Webster on Pediculoides

Webster on Pediculoides

season, has varied from one to ninety-five per cent. Here, too, we have found the mite generally in the cells in the straw occupied by the joint worm larvae. It has been found that in central Ohio, September sown wheat was much more seriously affected by the joint worm than that sown in October, and also that the infestation is worse in both cases on poor soil than on that of an average degree of fertility, and still less on good soil. The infestation was invariably worse in fields lying adjacent to or where wheat had been grown the previous year. Another interesting fact was revealed, and that is that fall plowed fields showed the least infestation of all. Therefore, it appears that moderately late sown wheat on good soil and on land not devoted to wheat the previous year, nor lying adjacent to such fields, has escaped with the least injury, and that less difficulty with the dermatitis is experienced where such wheat has been threshed from the field and as soon as possible after the grain was harvested. As the joint worm winters over in the stubble, where this can be burned during the fall, winter or spring, the destruction of the pest in the field will be complete. Where this cannot be done, much good may be accomplished by raking over in the spring the last year's stubble fields and burning the stubble thus collected. So important are these measures that practicing physicians might almost include them with their prescriptions for this painful skin disorder.

Explanation of Plates.

Plate III.

Fig. 1. *Pediculoides ventricosus* Newport, ungravid ♀. Stage in which the mite is both migratory and predatory and in which it attacks humans. From photograph by Dr. Jay F. Schamberg. Greatly magnified.

Fig. 2. The Angoumois grain moth, *Sitotroga cerealella* Oliv., *a*, eggs enlarged; *b. b.*, bernels of wheat infested by larvae; *c*, larva, enlarged; *d*, pupa; *e*, moth with wings spread; *f*, same with wings closed as at rest. Figs. *b.b.*, original remainder, after Chittenden, Farmers' Bulletin, U. S. Dept. Agriculture, No. 45, p. 6.

Fig. 3. *Pediculoides ventricosus*, gravid ♀. Greatly enlarged. Redrawn from Brucker.

Plate IV.

Illustrating various forms of the dermatitis lesions caused by attacks of *Pediculoides ventricosus*. From Photographs by Doctor Schamberg.

Plate V.

Fig. 1. Lesions caused by bites of *Pediculoides ventricosus*, in experiment of Dr. Joseph Goldberger. From drawing by F. H. Wilder. Courtesy of Public Health and Marine Hospital Service.

Fig. 2. Showing reduction in yield of wheat attacked by jointworm, *Isosoma tritici* Fitch. The tube at left contains yield from 100 heads from uninfested straws: tube at right contains yield from 100 heads from infested straws. Photographed by W. J. Phillips, Bureau of Entomology.

Fig. 3. Showing attack of joint-worm, *Isosoma tritici*, in field. Note the enlarged and distorted stems. From photograph by Geo. I. Reeves, Bureau of Entomology.

MYRMELEONIDÆ FROM AUSTRALIA.

By Nathan Banks.

The ant-lion flies of Australia have been mostly described by Walker and Gerstaecker. In collections sent to me by Mr. Dodd, from Kuranda and Port Darwin, and by Mr. Perkins, from several parts of Queensland, are a number of the described species and several that are new. These are described in this paper.

The Australian Myrmeleondiæ are more like the European forms than like those of the United States. Two genera, *Myrmeleon* and *Acanthaclisis*, they have that occur also with us, but these genera are generally distributed throughout the world. The new general are more allied to the European than to our genera. There is practically no similarity to the South African forms.

The eight genera known to me can be tabulated as follows:

1. No spurs, one cross-vein, before radial sector in hind wings; wings broad **Chrysoleon**
   Spurs present 2
2. One cross-vein before radial sector in hind wings 5
   Several cross-veins before radial sector in hind wings; anal ends before fork of radial sector; pronotum broader than long 3
3. In middle of apical half of each wing is a nearly straight line formed by the bent longitudinal veins and very short cross-veins; anal vein of hind wings runs into lower cubitus, legs short and stout . . **Acanthaclisis**
   No such line of bent veins and short cross-veins 4
4. In both wings the upper cubitus and the median unite long before margin of wings; wings very broad . . . . **Callistoleon**
   Upper cubitus and median not united, wings more narrow . . **Myrmeleon**
5. Basal joint of tarsi longer than apical joint; anal ends far out on wings, beyond origin of first fork of radial sector . . . . **Protoplectron**
   Basal joint of tarsi not longer than apical; anal vein ends nearer base of wing, at or before origin of first fork of the radial sector 6
6. Spurs as long as first four tarsal joints together . . . . **Distoleon**
   Spurs barely longer than first joint of tarsus 7
7. Wings broad in stigmal area, in middle of this area is a straight line as in Acanthaclisis formed by bent longitudinal veins and very short cross-veins . . . . **Glenurus**
   Wings more narrow; no such line formed by bent veins and short cross-veins **Formicaleo**

Glenurus pulchellus Ramb.

Mid-Queensland (Perkins) also New South Wales (Froggatt).

Glenurus dissolutus Gerst.

Port Darwin, 12 May (Dodd).

Glenurus stigmatus, n. sp.

Face pale, a large interantennal black spot, a transverse pale band above this, and the vertex brown; antennæ black; pronotum with a broad black median stripe, containing a pale median stripe in fore part, sides pale, streaked and dotted with black; rest of thorax black, with a few small pale spots on the lobes; abdomen black; legs black, tibia I and II with basal and preapical bands pale, sometimes also a median spot above; hind tibiæ pale behind, except tip, and in front at

base and tip pale; base of first tarsal joint pale; legs with short black hair and longer, erect bristles; spurs rather longer than first tarsal joint. Wings hyaline, with many small dots, mostly on forkings of veins, and in apical part, larger ones along radius and cubitus, forming rather oblique lines at ends of anal veins, and on gradate series in fore-wings; stigma a large, black spot in both wings, very prominent; wings of usual shape and much like *G. dissolutus*.

Expanse 80 mm., abdomen long 20 mm. From Kuranda, Queensland, Australia, March, (Dodd).

Protoplectron costatus n. sp.

Face pale, black in antennal region, vertex pale, a transverse black line, and behind it a row of spots, a small trapeze in the middle and two spots each side toward eye; antennæ pale brown, short, with large knob; pronotum brown, darkest behind on sides, paler in middle, with some long white hair, and also on the pleura; abdomen brown, with extremely short white hair; legs pale, femora dark above, tibiæ black at base and tip, tarsi black in middle, pale on most of first and fifth joints, with much long white hair, and some black bristles; tarsal joint I much longer than IV, one-half as long as tibiæ, spurs as long as first joint. Wings hyaline, narrow, acute at tip, and fore wings rather falcate; venation mostly dark, but some patches of cross-veins wholly yellow, and long streaks of pale in the longitudinal veins; stigma brown at base. In fore wings the lower cubitus runs parallel to anal vein for a long distance; but one series of costal cells in either wing; eight branches of radial sector before stigma in fore-wing.

Expanse 48 mm., abdomen 18 mm.

From Port Darwin, Australia, 10 April (Dodd).

Protoplectron pallidum n. sp.

Lower part of face yellowish, upper part and the front black; vertex with a broad transverse pale band from eye to eye, divided on the median line; antennæ yellowish brown, the second joint with a darker ring; pronotum pale yellowish; thorax dark brown on sides, pale through the middle, and a pale spot above base of each wing; pleura mostly pale or light brown; abdomen black, legs pale, rather reddish on femora and tarsi, no bands or marks, clothed with long white hair and black bristles. Antennæ rather longer than head plus thorax; pronotum once and a fourth longer than broad, only slightly narrowed in front; abdomen short, not near as long as wings. Legs rather short; tarsi very slender, basal joint more than one half as long as tibia, the spurs of the same length, joints 2, 3, and 4 very short, 5th joint more than one-half as long as the first, on its basal part beneath are several short, curved spines forming a comb. Wings yellowish hyaline, unspotted; stigma scarcely visible; venation yellowish, or brownish yellow, not dotted. Wings moderately slender, acute at tips, a double costal series of cells in fore wing, single series in hind wing; about 7 cross-veins before origin of radial sector in fore wing, only one in hind wing; in fore wing the first branch of

the radial sector arises long before end of the anal vein, which is nearly one-half way out on the hind margin; apical portions of both wings have the longitudinal veins very close together.

Expanse 58 to 68 mm., abdomen 20 mm.

Several specimens from Port Darwin, Australia, 8 April to 4 May, (Dodd).

Callistoleon n. gen.

Wings rather broad; anal veins of fore-wings ending long before origin of the first branch of the radial sector; posterior branch of cubitus running obliquely down toward anal vein, two series of cells between it and anal vein; about seven cross-veins before origin of radial sector in fore-wings, some crossed; a single series of costal cells; the anterior branch of cubitus and the median vein unite before tip, and from the anastomosis the veins radiate somewhat, to the margin, more strongly so in the hind wings. In the hind wings about four cross-veins before radial sector; the posterior branch of cubitus running obliquely down to margin, before origin of radial sector; head rather broad; antennæ moderately long, pronotum broader than long; tarsal joints short, first much shorter than fifth; spurs a little longer than basal joint.

Type—Myrmeleon erythrocephalum Leach.

Callistoleon erythrocephalum Leach.

Mid-Queensland (Perkins).

Distoleon n. gen.

Wings rather narrow; seven cross-veins before radial sector in fore wings, one in hind wings; anal ends before origin of first branch of radial sector; a single costal series. In hind wings anal ends soon after origin of lower cubitus, not parallel thereto. Spurs as long as first four tarsal joints, fifth joint much longer than first; tarsus I about as long as tibia I; pronotum broad.

Type—D. verticalis; also includes Formicaleo bistrigatus.

Distoleon verticalis n. sp.

Head pale, a black band below and one above base of antennæ, another band above this, narrowly interrupted in the middle or broken into four spots, and on the vertex four spots forming a trapeze in the middle and two each side toward the eye; antennæ brown, annulate with pale; pronotum pale, darker on margin, rest of thorax grayish brown, abdomen blackish, a pale spot above in middle of each segment, legs pale, some black dots at bases of bristles, black and white bristles. Wings hyaline, a dark dot on stigma, one on hind margin one-third the way out at end of anal vein, and two at end of cubitus and median veins, and other smaller spots in apical part of wing, and at forkings of longitudinal veins, these veins black and white in long streaks, some cross-veins all black, others all yellow, others black and yellow. Hind wings with two dots at end of cubitus and less distinctly on apical portion. Antennæ long; legs short, spurs

heavy, curved, as long as first four joints, fifth joint twice as long as first. Pronotum broader than long, not narrowed in front. Wings rather long acute; one costal series, cells in region of gradate series are long and narrow.

Expanse 68 mm., abdomen long 25 mm.

Mid-Queensland, Australia, (Perkins).

Distoleon bistrigatus Ramb.

(M. striola Walk.)

Port Darwin 20 April, 28 August; Kuranda, March; Mid-Queensland.

Chrysoleon n. gen.

No spurs; legs slender, first tarsal joint as long as second plus third, hardly as long as the fifth; pronotum slender. Fore wings broad, hind wings narrower and longer than fore wings; costals of fore wings frequently forked; three cross-veins before radial sector; anal ends a little beyond origin of first branch of medial sector; a double series of anal cells; the lower cubitus running obliquely down to the hind margin. In hind wings one cross-vein before radial sector; anal ending beyond origin of first branch of radial sector; lower cubitus running down to margin, upper cubitus uniting with median before tip of wing.

Chrysoleon punctatum n. sp.

Head yellow, a faint dark mark each side on vertex; antennæ yellowish, darker at tip; pronotum pale, with some scattered brown dots; rest of thorax mostly pale; abdomen pale, a black stripe each side; legs pale, minute brown dots at base of bristles, not distinct on hind tibiæ. Wings hyaline, outer apical part of fore wing with small brown clouds at forks of veins, and one under the stigma, also in hind wing, but fewer in the posterior apical part. Venation pale, frequently dotted with brown in fore wings, especially along cubitus. Antennæ short, not reaching beyond middle of thorax; pronotum slender, narrowed in front, this and the rest of thorax with long white hairs, abdomen with short white hair; legs with some long white hairs and black bristles. Fore wings broad below stigma, barely acute at tips, cells of wing small and irregular; radial sector seven branched before stigma; costal area broad, the cells narrow.

Expanse forewings 43 mm., hind wings 47 mm., abdomen long 13 mm.

From Port Darwin, Australia 20 April (Dodd.)

Formicaleo dispersus n. sp.

On the same general plan as *F. septus* and *F. bistrigatus*, but no dark stripes in front wings instead of which are about twenty small dark spots in the area of the stripe of *F. septus* toward the hind margin, and in hind wings is a stripe as in *F. septus* but its apical part broken up into small spots. The head is yellow, a large black spot on front and upper face; antennæ pale on basal part, brown

toward tip; pronotum pale yellowish as also thorax, abdomen rather darker on sides and near tip. Legs pale, unmarked, black bristles; spurs as long as joint I, 5th joint as long as rest together. Wings of general shape of *F. septus*, and similar in venation, seven cross-veins before origin of radial sector in fore wings, one in hind wings; from end of anal vein there is no vein bending up and outward as in *F. bistrigatus*, in this respect like *F. septus*.

Expanse 54 mm.; abdomen long 17 mm.

From Port Darwin, Australia, 13 March (Dodd).

Formicaleo marginalis n. sp.

Pale yellowish; a broad black stripe through antennal region from eye to eye; vertex with two black submedian spots, and a median spot behind them; antennæ pale brown; pronotum with two dark spots on front margin and a stripe behind each of them to the hind border; thorax striped with dark, a submedian pair in front reaching to middle of mesothorax, a lateral one just above wing, and a short pair on metathorax, and a dark spot over base of wings; pleura with some black spots, mostly on lower parts; abdomen blackish, with short white hair; legs pale, with black bristles, and short black hair. Wings unmarked, except at posterior margin near tip of both pairs where the margin is infuscate for about one-third the way from tip to base; venation yellow, subcosta interruptedly black in both wings, and some dark dots on cubitus in fore wings. Venation similar to *F. bistrigatus*, a vein bending upward and outward from end of anal vein in fore wings, seven cross-veins before radial sector in fore wings, one in hind wings. Pronotum rather slender, narrowed in front; legs short, tarsal joint I about as long as II plus III, much shorter than V, spurs a little longer than first joint.

Expanse 43 mm., abdomen long 13 mm.

From Kuranda, Queensland, Australia, March, (Dodd).

Formicaleo septus Gerst.

Port Darwin, latter part March through April; also at Kuranda, March.

Myrmeleon pictifrons Gerst.

Port Darwin; common, 10 to 21 April; and also 3 September; Mid-Queensland (Perkins).

Myrmeleon uniseriatus Gerst.

Port Darwin, 9 September; Mid-Queensland.

Myrmeleon croceicollis Gerst.

Kuranda, March.

Acanthaclisis fundatus Walk.

Kuranda, March (Dodd); Mid-Queensland, (Perkins).

Acanthaclisis subtendeus Walk.

From Kuranda, March (Dodd).

THE ANATOMY OF THE LARVA OF CECIDOMYIA RESINICOLOIDES WILLIAMS.

By Francis X. Williams.

In the January number of Entomological News, Vol. XX, 1–8, 1909, I described this midge in its egg, mature larval, pupal and imaginal instars, and gave a brief biological report on it. The curious habit of the larva in living in a mass of exuding resin might be expected to have brought about some adaptive modifications of its structure, especially perhaps of its tracheal system. It is for this reason particularly that the attempt has been made to study the larval structure in detail. As much of the anatomy of the larva is described here as could be worked out in a limited time, and although over a hundred larvae were examined and dissected, the results are far from complete. Considerable difficulty was encountered in tracing out the various systems of the larva, and the writer has deemed it best to omit the doubtful things and to declare only those facts which were made manifest over and over again by the examination of a large number of specimens.

The work embodied in this paper was done in the entomological laboratory of Stanford University.

EXTERNAL ANATOMY OF THE LARVA.

Head, Pl. I, Figs. 1 and 2. The head is very small and imperfectly developed. Its brownish-black chitinized portion consists of a broad irregular ring from which a pair of prong-like rods project well into the supernumerary segment. These rods diverge posteriorly, are more heavily chitinized than the ring, and have muscles attached to them that run from the body wall. The antennae are short, conical, obscurely two-jointed processes placed well above the opening of the mouth. Ratzeburg and L. Defour believe these processes are palpi, but Osten Sacken as well as Laboulbene and Perris, from the position of these organs, consider them rudimentary antennae. I incline to the latter view since they are situated latero-dorsally on the anterior part of the ring and well above the mouth opening. This latter consists of a soft, fleshy swelling taken by Ratzeburg for the labium.

Breastbone, Pl. I, Fig. 3. Ventrally on the posterior half of segment I, and situated in a sort of fold is the "breastbone,"

also known as the "sternal spatula" or "anchor process," an organ said to be peculiar to the *Cecidomyidae*. This is a brownish chitinized process varying somewhat in shape, but usually widest at the extremities, slightly constricted at or near its middle and at the caudal end, and somewhat incised anteriorly where a small portion of it projects beyond a transverse fold. The caudal extremity is concealed under the posterior fold of segment I. The anterior incised portion of the spatula is somewhat scooped out, and the more heavily chitinized central axis sends out a ridge on either side of this depression. Otherwise the whole piece may be quite uniformly chitinized. A lateral view of this organ shows that it follows the curved outline of that part of the segment in which it lies.

The use or the homology of the "breastbone" has been a subject of some speculation. Giard (8) says that some of these Cecidomyid larvae have the power of leaping, using their well developed spatula and terminal corneus papillae for this process, and in this wise: the larva bends itself almost into a circle, and hooking together the breastbone and papillae breaks the connection thus formed and the spring occurs. In the species referred to by Giard however the spatula is well muscled, strongly chitinized, projects well externally, and the corneus papillae are developed. The advantage gained by this faculty of leaping is, according to Giard, the assurance of the dissemination of the species, which in turn insures an abundant food-supply and therefore the successful perpetuation of the species. The larvae of *Diplosis loti* and *jacobeae*, cited as examples by him as having this leaping power, are gregarious and would not leave enough food for their descendants if they were not thus motile. This theory does not seem adequate inasmuch as the adults look after the food-supply for their progeny, and being active and winged, would have no difficulty in finding another suitable plant on which to oviposit. The motile habits of the larva brought into play just before pupation would indicate a search on the part of the insect for a proper place for pupation, the pupa being formed underground and probably at no great distance from the abandoned food-plant. In *C. resinicoloides* the spatula is not well developed, projects but slightly anteriorly, and the posterior corneus papillae are absent, also as the insect lives both in the larval and pupal stages in pitch, the breastbone could hardly be used as a locomotor organ. In fact it does not appear to be con-

nected with any muscles. Owing to the medium in which the larva lives, it is possible that it has lost this power of leaping by the degeneration of the organs so well developed in the saltatorial Cecidomyid larvae. Locomotion in the larva of *C. resinicoloides* is chiefly, if not wholly, accomplished by the extension and contraction of its spiny segments, with the possible assistance of the pseudopod-like processes.

Another theory advanced to explain the use of the breastbone is that it is used as a perforator (17). It could thus be used in some gall-forming species which pupate outside their gall, to force an exit therefrom. L. O. Howard (11) refers to a view proposed by Enock and sustained by Marchal according to which the spatula is used to reverse the position of the larva in the puparium. In the case of *C. resinicoloides* this last theory might apply, but it seems more probable that the spatula is used in making the cocoon, in pushing out a space in the resin, and forming the thin, convex cocoon cap. Inasmuch as, according to Giard, the spatula is only fully developed in the last moult, it is quite evident that this organ is intimately associated with the prepupal actions of the larva. Osten Sacken says (14): "If the supplementary (14th) segment be considered as a part of the head, this breastbone might be taken for the mentum, in analogy to the horny mentum of the larvae of the *Tipulariae*."

Pseudopods. These are rounded, somewhat nipple-like processes, most prominent on the thoracic segments and usually in double pairs on the segments. Segment I has a pair on each anterior side of the spatula and bordered anteriorly by the imaginal leg discs; segments 2 and 3 have each a more prominent double pair, transversely arranged in the middle of the segments and likewise bordered anteriorly by the leg discs, those of the wings being lateral; segment 4 has an inconspicuous pair of pseudopods; segment 10 some indistinct protuberances; while on segment 11 are a pair of rather widely separated protuberances anterior to the anal slit. The last or 12th segment is terminated by two conical projections bearing a bristle at their apices.

Spiracles. There are nine pairs of spiracles, normally situated, one on the first thoracic segment and one each on segments 4–11. The last pair is placed apparently on the last segment, but Osten Sacken (14) has pointed out that this segment is in reality the 8th abdominal, the 9th being in *C. pini* and *C. pini-inopis*, (the latter being considered a synonym of *C. resinicola*) unusually

small and concealed under the 8th abdominal segment. The spiracles are horny, conical projections placed somewhat above the lateral line, especially on segment 1. The anal spiracles are far larger than the lateral ones, and are of most importance to the larva. They are truncated conical, with four stout spines. No young larvae were examined, but Eckel (5) says of the related *resinicola*: "The tracheal system undergoes no change with the larval growth except the odd development about the anal spiracles." In the young *resinicola* larva each terminal spiracle is a long horny tube, whereas in full-grown specimens they resemble those of *resinicoloides*. The 3rd thoracic segment has no spiracles although the tracheal tube is present here and well developed. Eckel has noted this in the eastern species.

Hairs and Bristles. These may be divided into two classes: (1) longer sparse hairs; (2) shorter numerous bristles. Those of the first class are, as far as could be ascertained, present on all but the supernumerary segment. On segments 4–10 are two larger hairs situated one below the other, the first close to the base of the spiracle. On segment 11, laterally and just below the spiracle is a large hair. On segment 12 are two apical hairs already referred to. These hairs, commonly near the spiracles, may assist in keeping the latter clear of the soft resin in which the larva lies.

The bristles* are arranged in transverse rows forming long patches on the dorsal and ventral surface of the body and thinning out laterally. Dorsally these bands are on the anterior portion of segments 2, 3, 4, 5 and 6, and on the posterior part of segments 8, 9, and 10. The band is heaviest on segment 4 where a blank space cuts out a broad mesal notch on its posterior border. On segments 2 and 3 the band is broad and almost divided by a transverse space, and on segment 5 is further reduced to three patches. The patch on segment 6 is almost obsolete. These bristles point posteriorly while the simple bands on segments 8, 9 and 10 have them pointing anteriorly.

Ventrally the bristle rows are not broken up but are simple, and are present on the anterior part of segments 2, 3, 4, 5, 6, 7, 8 and 9 where they point posteriorly and on the posterior portion of segments 4, 5, 6, 7, 8, 9, 10 and 11, where they point anteriorly. These rows pointing forward thin out anteriorly, and on seg-

* Illustrated in Ent. News, XX, Jan., 1909, Plate I.

ment 4 are quite small and inconspicuous, whereas the sets pointing backward become thicker anteriorly. We see then that these rows of bristles are heaviest at either end of the larva and absent or imperfectly developed along the middle of the body, there being a gradual transition from the posterior—to the forward—pointing bristles. The bristles thin out laterally and are more numerous on the venter than on the dorsum.

Although the larva is not an extensive traveller, it is nevertheless quite active and moves about considerably within the limited space of the resinous mass in which it lives. It cannot survive very long when completely submerged in the gummy exudation, but lives with its anal spiracles at the surface of the mass or in a hollow therein, while its mouthparts are in close proximity to the abraded cambium. It must also turn itself around in its cocoon before pupation. It was observed that the posterior portion of the larva is usually more extended and the cephalic end often more contracted. When the larva desires to advance, its anterior segments are extended, thus exposing the strong rows of backward-pointing bristles, while the hinder end is somewhat drawn in, thus concealing its bristles, and, by contracting and expanding the anterior segments the desired movement can be obtained. It would not seem of so much importance that the larva move its whole body backwards, but that it extend its caudal spiracles to an opening for air is quite imperative. Thus it could firmly anchor its cephalic end to a desired spot, and by means of the forward-pointing bristle rows extend its spiracles to the surface. By sufficient contraction the rows of bristles at one end could be completely concealed and those of the other end fully exposed and brought into play. The pseudopods may also assist in the movements of the larva.

INTERNAL ANATOMY.

Tracheal System. Pl. VI, Figs. 4 and 5. This was very carefully worked out, the tracheal arrangement being followed to the finest ramifications. As in other insects it consists of longitudinal trunks connected with the spiracles by lateral branches. Figs. 4 and 5 of plate VI shows this system from a dorsal and ventral aspect, of a larva submitted to some pressure under a coverglass. It consists of a pair of longitudinal dorsal trunks beginning at the spiracles of segment 1 and terminating in the caudal spiracles of segment 11. At G, Fig. 4, a stout branch is

sent ventrad, which divides almost immediately, the one branch proceeding to the head while the other, bending posteriorly, supplies the brain and sub-œsophageal ganglion. This posterior branch is F_1, in Plate VI, Fig. 4.

The two dorsal trunks are connected with the spiracles by short branches and are joined to each other in segments 4–9 and 11 by cross tubes, that of segment 11 being quite stout while the rest are slender and send out two re-dividing branches. These cross-tubes usually lose their striated appearance at their middle, appearing composed of two tubes fused together by a pair of sponge-like knobs. In segment 10, there is no fusion, the tubes remaining separate. Fig. 6, E_{10}, Pl. VI, shows a condition observed in two larvae in which the left branch is quite swollen basally, which perhaps was the normal thickness of both tubes, throughout before atrophy occurred and the tubes separated. The fact that in *C. resinicola* there are complete cross tubes in segments 4–11 would appear to strengthen this view. Furthermore it will be noticed that in *C. resinicoloides* the cross tube in segment 11 is quite stout and may substitute in a measure for the tubes in the above segment. Ramifying tracheae are apparently not so necessary in the last few segments.

The transverse lateral tubes D_3—D_{10}, Fig. 4, terminate in the spiracles except in segment 3 where there is no spiracle, in which case the tube disappears near the body surface. They are connected with one another either by the lateral longitudinal system through the short tube R_3, R_4, etc., as in segments 3–8, or they may run directly through the former, as in segments 9 and 10. This arrangement, however, is frequently asymmetrical.

The lateral longitudinal trunks arise from the dorsal ones in segment 2, Fig. 4, A_2, Pl. VI, and terminate as free branches in segment 10, C_{11}, Fig. 4, and apparently correspond to the ventral tubes as illustrated by Eckel (5), but differ widely from the latter in that they do not join the dorsal trunk posteriorly. They send out many branches F_2, F_3, K_4, K_5, etc., but the arrangement of these is not always constant. The primary function of the more anterior of these branches is to aerate and support the nervous system, that of the more posterior ones to supply the Malpighian tubules.

The ventral longitudinal system Fig. 5, Pl. VI, arises from the main dorsal one close to the anal spiracles in segment 11, and proceeding anteriorly commences ramifying in the middle of

segment 8, where it turns dorsally, closely following the Malpighian tubes to which short branches are sent.

Circulatory System. This system owing to its transparency and delicacy was quite difficult to follow, and so a detailed description of it cannot be presented. The dorsal vessel is a thin-walled, transparent tube which arises in front of and below the brain, and proceeds obliquely upwards until it meets the body wall in the posterior part of segment 4 where it is secured by the suspensorium. Thence it runs along the dorsum extending at least to the posterior transverse tracheal tube. It is divided into chambers and the valvular orifices (ostia) on either side open and close inwardly. The dorsal vessel pulsates especially in its anterior portion where there are several orifices. On each side of the heart in the middle of segment 4 is a strip of loose periçardial cells which proceed posteriorly, closely following the vessel.

Alimentary Canal. Pl. VII, Fig. 1. The alimentary canal consists of the long slender œsophagus D, the larger scarcely differentiated fore- and mid-stomachs (proventriculus and ventriculus) G, the slender and much curved ileum or small intestine I, the colon K, and the rectum L. A pair of long, recurved salivary glands C. F. open into the mouth, and two Malpighian tubules H, likewise recurved, are fastened to the fore part of the ileum. The whole system is supported chiefly by the tracheæ.

Lying above the œsophagus and salivary glands and extending well beyond the rods of the head skeleton is a large blind sac, S, Figs. 1 and 2, Pl. VI, which probably opens into the mouth. It contains in its middle a curious, dark purplish-brown object, A, Figs. 1 and 2, Pl. VI, which is lobed anteriorly, and posteriorly where it becomes semi-translucent and breaks up into small granules. This object is evidently the "*point oculiforme*" of Giard (8), who noted it also in a Cecidomyia, but what its function is he does not state. The large blind sac is apparently not muscular, though it is possible that it may serve as a food reservoir. The "*point oculiforme*" suggests a strainer of some sort, especially if the sac were muscular. The œsophagus extends to the end of segment 3 as a very slender and delicate tube, and is chitinized within the rods of the head skeleton, C, Fig. 2, Pl. VII, and Fig. 6, Pl. VII.

The large, straight, muscular stomach extends from the 4th to the 8th segment inclusive, and its cellular coat is made up of

more or less regular longitudinal rows of large protruding cells. The whole canal, including the salivary glands and the Malpighian tubules is clearly visible through the larval body wall.

In the posterior portion of segment 8 the slender ileum arises abruptly from the thick ventriculus as a curved and folded tube. Its cellular wall consists of several rows of large cells distinct in the anterior orange portion, less so in the whitish translucent middle part, and disappearing in the slenderer hinder end, which opens into the delicate grayish colon. The rectum is a rather colourless tube of considerable length terminating in the anus on segment 11.

The extreme hind part of the canal probably functions but little, except perhaps when the larva is near pupation. It was not seen to contain any waste matter, and if the larva was submitted to considerable pressure under a coverglass no excrement would be discharged.

Glandular and Excretory Appendages of the Alimentary Canal. The salivary glands are of large size and extend along each side of the ventriculus to the middle of segment 6 where they recurve dorsally and proceed to the anterior end of segment 5, being fastened to the ventriculus at that point. The larger posterior portion of the glands are glassy white and of moniliforme aspect, with several rows of large glandular cells containing large nuclei. At about the middle of segment 3 the glands become narrower, lose their glassy, large-celled appearance, and twisting spirally downwards, then upwards, dilate abruptly into granular ampullae of a pale yellowish-white color. These are three in number, two larger posterior ones and a single inconspicuous anterior swelling. From this latter point the glands taper gently, and at about the posterior border of the supernumerary segment give place to the tracheoid ducts. These are short slender tubes and join to form the common duct, B, Fig. 2, Pl. VI, a short distance within the chitinous rods of the head skeleton.

Whether the secretion of the salivary glands of the larva produces an irritation in the plant tissue thereby causing a flow of resin, or whether "the twistings of perhaps a dozen spiny-skinned larvae smooth out a round cavity" (in the resin), "the irritation causing a constant supply of fresh resin," to use Eckel's own words as regards *C. resinicola*, is a difficult thing to determine. Giard (9) thinks that the "zymase" secreted by the salivary

glands of the Cecidomyid larva determines the gall. No gall is formed in the case of the pitch-inhabiting midges, but the salivary secretion in this case might well stimulate and maintain the resinous exudation.

Attached interiorly to the second ampulla of the salivary glands and stretching in a curve across the brain which it overlies very closely is a curious, loose ill-defined structure of granular appearance, F, Fig. VII, Pl. 2, and containing brown patches, especially towards the bases. This I believe is Weismann's "cell chaplet," which he defines thus: "It consists of a string of large cells closely united which hangs like a garland, free in the body cavity. Its two ends are connected with the salivary glands," etc. What its function is remains to be ascertained.

The Malpighian tubules are of a deep orange color and arise from the anterior end of the ileum immediately where the latter is joined to the ventriculus by a delicate membrane. The arrangement of these two tubules with regard to the ileum and colon is not symmetrical since the left one follows rather closely those two divisions of the proctodæum, while the right tubule is quite free. Fig. 5, Pl. VII shows the left tubule in its relation to the proctodæum. Arising from the ileum each tube proceeds dorsally but not quite in symmetry as the right tube bends anteriorly and outwardly while the left first curves somewhat posteriorly, P, Fig. 1, Pl. VII and then follows the common course. Each tube is closely appressed to the ventriculus to which it is slightly fastened and proceeds anteriorly past the middle of segment 7. Here however the left one by reason of its posterior bend does not reach quite so far forward as its mate, but terminates slightly farther posteriorly and ends somewhat beyond the middle of the colon. Both tubes run along the ventral tracheal trunks in their terminal portions.

Giard says (10):—"In all the larvae of the Cecidomyidæ which I have studied, these tubes, two in number are united into an elegantly recurved handle, and open near the anus, the proctodæum being excessively short." In *C. resinicoloides* the tubes end freely, as we have seen, and the proctodæum, if extended would probably at least be as long as the rest of the alimentary canal.

It may be well said here that the alimentary canal (and its appendages) of *C. resinicoloides* much resembles that of *Diplosis buxi* illustrated by Berlese (2).

Organs of Reproduction? At about the termination of the Malpighian tubules, and below the same is a pair of elongate, fusiform, transparent bodies terminating anteriorly and posteriorly as slender tubes. These bodies were not observed in all the larvae examined. They are probably the developing reproductive organs.

Nervous System. Plate VIII, Figs. 1 and 2. The nervous system is more specialized than in many other dipterous larvae, in that there is considerable cephalization of the ganglionic chain. This chain is composed of ten distinct ganglia, exclusive of the sub-œsophageal one, and extends from the middle of segment 2 to the middle of segment 4. It is supported chiefly by the converging branches of the lateral longitudinal tracheae, while the brain is kept in place and aerated largely by the stouter pair of tracheal branches, F_1, which arise from the main dorsal system.

The brain or supra-œsophageal ganglion consists of two lobes of larger size than the rest and broadly joined to the sub-œsophageal ganglion, the commissure not being apparent. The œsophagus passes between these two ganglia, as probably also the dorsal vessel, the salivary glands running on either side. At least one pair of nerve cords from the brain, and two or more from the sub-œsophageal ganglion proceed anteriorly, and each of the ganglia of the chain sends out several nerves, some of which run along the lengths of the supporting tracheae. The last ganglion of the chain is more elongate than the others.

Very little could be made out of the sympathetic nervous system, and the paired ganglia, C, Figs. 1 and 2, Pl. VIII, arising posteriorly from the lobes of the brain are all that I feel sure of.

Musculature. The muscles were not studied though it was observed that they were numerous and well developed, a condition quite necessary in such a restless insect. Several muscles are fastened to the chitinous prongs of the head skeleton, and a number of large muscles radiate from the caudal cleft, being fastened to the body wall. Thus the larva is enabled to retract quickly its caudal end into the resinous mass if disturbed.

Adipose tissue. This is very well developed, so much so indeed that it obscures in a great measure the different visceral systems. The fat body is of a dirty yellowish-white color, and consists of a loose network of lobes with long meshes, and is continuous throughout the body, thickest below the middle, thence tapering to either extremity, extending anteriorly to the base of the

first pair of spiracles, and posteriorly to near the anus. It is circumscribed and largely supported by the tracheal system. Some time before pupation this fat tissue loses much of its compactness, becoming more or less watery in appearance and assumes a reddish color.

Imaginal Discs of Wings and Legs. Plate VIII, Figs. 6 and 7. These are easily seen in large full-fed larvae where they appear as more or less circular discs attached to the body wall.

The wing-buds, Pl. VIII, Fig. 7, A_2A_3, are larger than those of the legs, lie very slightly above the lateral line of the body, and are supplied with branches of the lateral and dorsal tracheae. Both wing- and balancer-discs arise from about the middle of their respective segments, ending posteriorly in a lobe and tapering anteriorly into the body wall.

The three pairs of leg discs, Fig. 6 A_1, A_2, A_3, are situated on either side of the ventral line and are more distinctly circular in outline than the wing discs and more strongly and completely cut by an inner ring. They are supplied by small branches of the lateral tracheae.

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EXPLANATION OF PLATES.

All figures greatly enlarged.

Plate VI.

Fig. 1. Dorsal view of head skeleton; S. blind sac; A, point oculiforme; O, œsophagus; B, salivary duct; N, nerve.

Fig. 2. Lateral view of head skeleton; S, blind sac; A, point oculiforme; B, tracheoid duct; O, œsophagus; N. nerve.

Fig. 3. Sternal spatula; A. A, A, dorsal view; B, lateral view.

Fig. 4. Dorsal view of tracheal system of mature larva; A_1—A_{11}, dorsal longitudinal trunk; B_{12}, ventral longitudinal trunk; C_2—C_{10}, C_{11}, lateral longitudinal trunk; D_3—D_{10}, lateral transverse tubes to spiracles; E_4—E_{10}, E_{11}, cross tubes; F, F_1, F_2—F_4, branches to nervous system; K_4, K_5, branches to nervous system; G, branch from dorsal trunk; H, branch to head; R_3, R_4, R_5, connecting branch between C and D; M, head; S, supernumerary segment.

Fig. 5. Ventral view of tracheal system of mature larva, lettering same as in Fig. 4, B_8, dorsal turn of ventral longitudinal trunk.

Fig. 6. Aborted cross tubes of Seg. 10.

Plate VII.

Fig. 1. Dorsal view of alimentary canal of mature larva; A, head; B, blind sac; C, ampullae of salivary glands; D, œsophagus; E, Weisman's cell chaplet; F, large-celled portion of salivary glands; G, ventriculus; H. Malpighian tubule; I, ileum; J, ventral longitudinal trachea; K, colon; L, rectum; M, anus; P, posterior bend of left Malpighian tubule

Fig. 2. Head skeleton and portion of salivary glands; A, antenna; B, head skeleton; C, œsophagus; D, common duct of salivary glands showing tracheal character; E, ampulla of salivary glands; F, Weisman's cell chaplet.

Fig. 3. Sagittal section through larva; A, adipose tissue; B, muscle; C, alimentary canal; O, œsophagus; I, ileum; P, Malpighian tubule; M, M_1, salivary glands; H, heart; S, blind sac.

Fig. 4. Cross trachea in segment 11 showing central spongy mass.

Fig. 5. Lateral view of proctodeum; A, posterior end of ventriculus; B, ileum; C, colon; D, rectum; E, anus; F, Malpighian tubule; L, L_1, slender portion of ileum; O, point of origin of Malpighian tubules.

Fig. 6. Chitinized portion of anterior end of œsophagus.

Fig. 7. Dorsal view of anal spiracles, 12—last segment.

Plate VIII.

Fig. 1. Dorsal view of nervous system; A, sub-œsophageal ganglion; B, brain; C, one of the paired ganglia of the sympathetic system; F, trachea feeding brain and sub-œsophageal ganglion.

Fig. 2. Lateral view of nervous system; lettering as in figure 1. T. trachea.

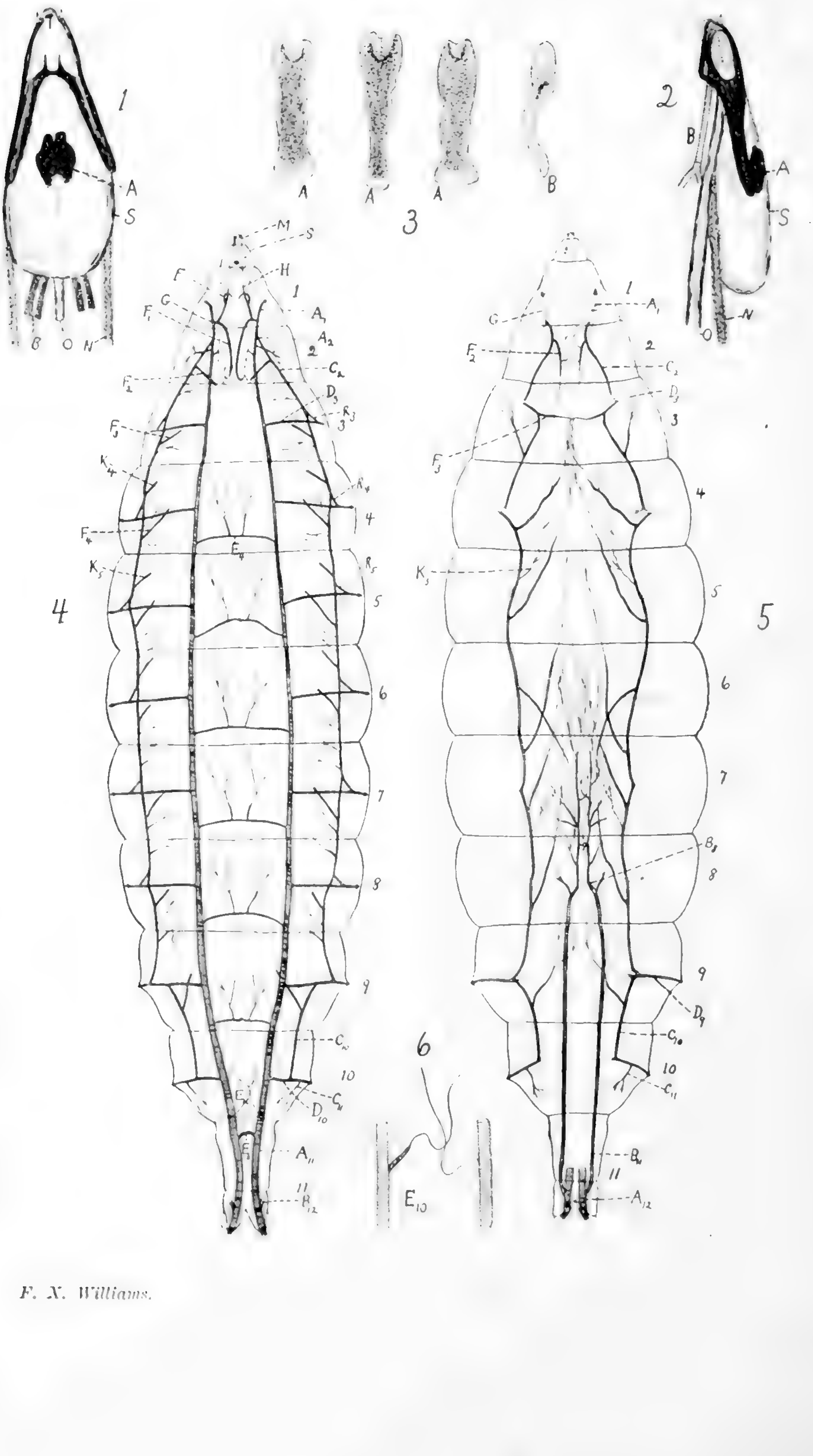
Fig. 3. Cross section through posterior portion of larva; A, adipose tissue; B, muscle; C, ventriculus; H, heart; M, Malphigian tubule; L, L_1, slender portion of ileum corresponding to L, $L_{.1}$, of Fig. 5, Plate VII.

Fig. 4. Cross section through ventriculus showing epithelial cells.

Fig. 5. Cross section through anterior portion of larva; A, adipose tissue; B, muscle; C. ventriculus; M. salivary glands; H, heart; F, pericardial fat cells.

Fig. 6. Ventral view of anterior portion of larva (portions of segments 1, 2 and 3) showing imaginal leg discs, A_1, A_2, A_3; B, dorsal longitudinal trunk of tracheal system; C, lateral longitudinal trunk; D, tracheal branch feeding brain, this is F_1, Fig. 4, plate VI.

Fig. 7. Dorsal view of portion of segments 2 and 3, showing imaginal wing discs, A_2 and A_3; B, dorsal longitudinal trunk; C, lateral longitudinal trunk.



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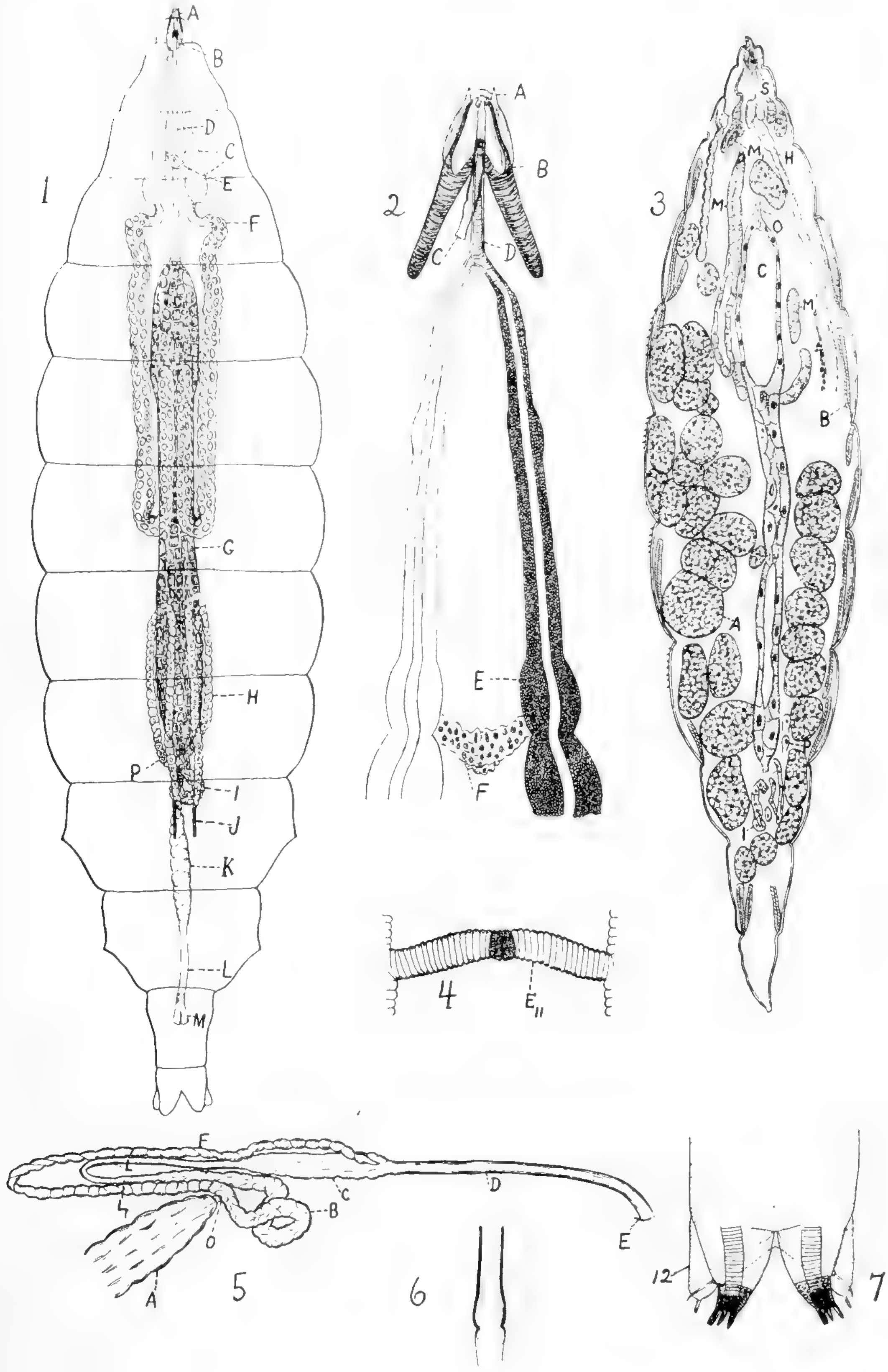

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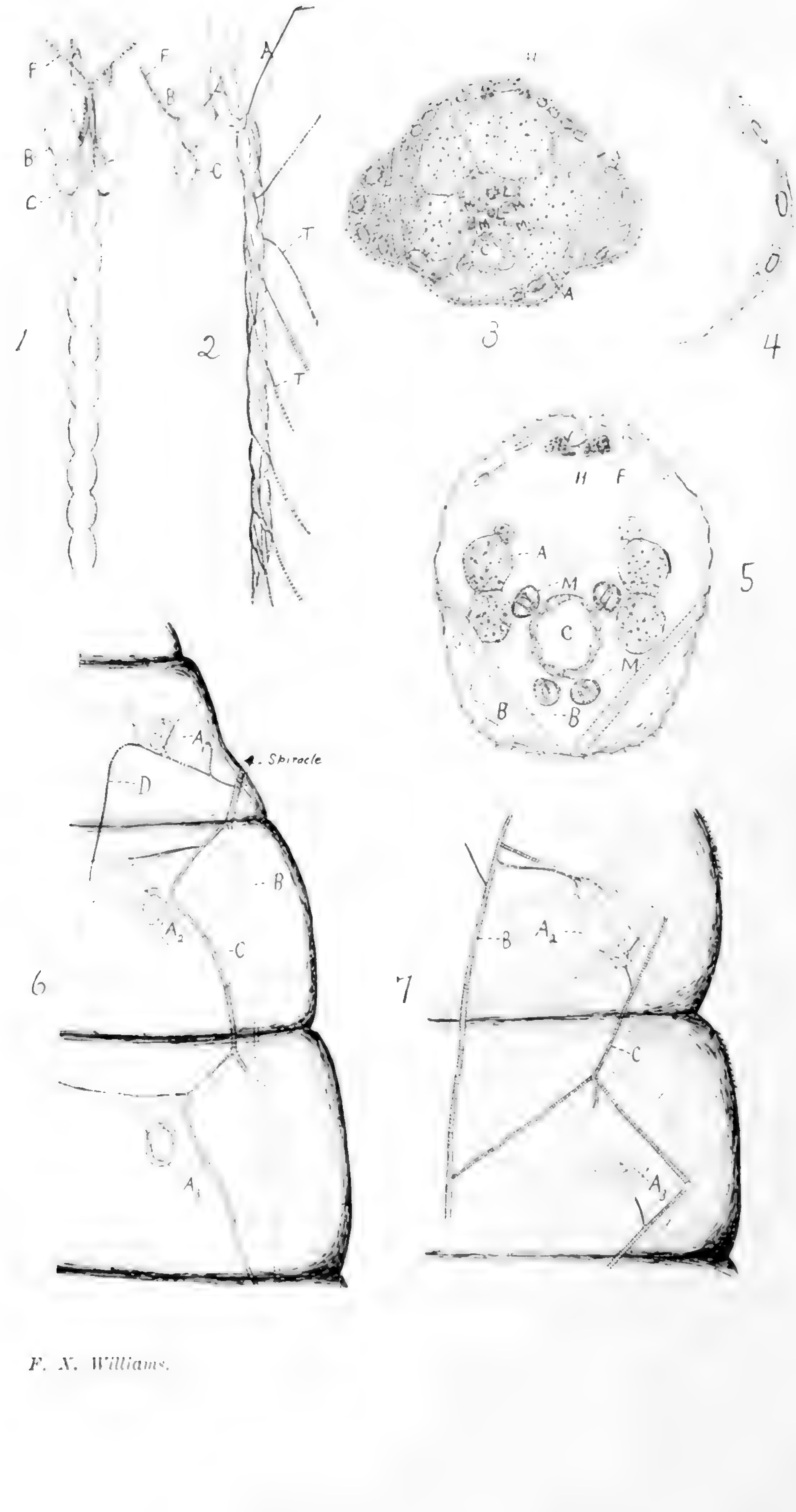

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SOME NEW FACTS ON THE BIONOMICS OF THE CALIFORNIA RODENT FLEAS.

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The thorough investigations which the United States Public Health and Marine-Hospital Service are at present undertaking in suppressing bubonic plague in California presented the writer with an opportunity to study the parasites associated with the transmission of the disease among rodents.

In this contribution we have not taken into account the factors involved in the epidemiology, but have restricted the scope of the paper to a discussion of the general habits and transformations of the California rodent fleas. Many of the observations on the bionomics of the fleas are quite different from those recorded by the investigators of the English Plague Commission in India. This is due in a measure to difference in climatic conditions, to which fleas as a rule are easily influenced; and the difference in the species of flea. The English workers confined their experiments to one species, namely, the *Loemopsylla cheopis* Roth. We have considered the rodent fleas generally, giving most attention to the squirrel flea *C. acutus* Baker.

FLEAS IN RELATION TO THEIR ENVIRONMENTS.

We have made an effort to rear fleas in the laboratory by attempting to duplicate conditions found to exist in nature. The human flea, *P. irritans* Linn, was found to develop very satisfactorily in a medium composed of floor sweepings taken from the cracks in the floor. The squirrel fleas and rat fleas were found to develop well in material taken from the nests of their respective hosts. We have experienced no difficulty in raising these parasites by placing animals covered with fleas in cages with a bedding of sawdust; and the only provision necessary for complete development was the addition of fresh sawdust to prevent the accumulation of too much moisture.

An experiment was made to determine in what media fleas away from the host would survive longest. For this purpose we tested various materials shown in the following table:

LENGTH OF LIFE IN VARIOUS MEDIA.

C. acutus.

Days Removed from Host	Dry Sand with Squirrel Droppings	Moist Sand from Squirrel Nest	Dry sand from Squirrel Nest	Sawdust Moistened with Horse Serum	Dry Sawdust	Moistened Sawdust with Wheat Grains
	* †					
2	5 M. 5 F.	10 F.	10 F.	4 M. 6 F.	4 M. 6 F.	4 M. 6 F.
7	2 M. 5 F.	4 F.	All dead	1 M. 3 F.	4 F.	1 M. 5 F.
9		1 F.		2 F.	2 F.	1 M. 4 F.
10	2 M. 5 F.	All dead		All dead	All dead	1 M. 4 F.
14	1 M. 1 F.					1 M. 3 F.
16	1 M. 1 F.					
17	All dead					1 M. 3 F.
20						3 F.
25						1 F.
26						All dead

*M—Male; †F—Female.

The controls 5 M. 5 F. were all dead on or before the seventh day.

In the medium of moistened sawdust mixed with a few wheat grains it was found that the wheat sprouted in the sawdust and held sufficient moisture to provide a suitable condition for larvae as well as for adults. The mould which formed in a short time did not seem to affect the insect life.

It is seen that the fleas did not fare well in the medium of dry sand. The sand was mixed with clay dust which would rise whenever the fleas hopped in the vial. As a consequence death resulted presumably by stoppage of the spiracles.

It will be seen from a survey of this table that fleas taken from the natural host may be kept alive without food for a considerable time. The medium of moistened sawdust with a few grains of wheat seemed to answer the moisture requirements for flea life.

LOCOMOTION.

The only literature that has come to our notice on the jumping powers of fleas appears in the Journal of Hygiene, 1906, Vol. 6, p. 464. Here we have a note: "It had previously been found that a rat flea could not hop farther than five inches." The species in question in these experiments was the *L. cheopis*, which is found to the extent of 99% on the rats in India.

It seemed desirable to learn the jumping abilities of the common California species. An attempt was made to determine the distance upon a horizontal plane, as well as the height that the insect could jump. In the broad jump a few experiments were conducted with *P. irritans*, the most active of our California fleas. In this species we have found the jumping distance varies considerably with the nature of the container from which the insect is observed, e. g., a foothold of wood enables the flea to jump a greater distance than one of glass. Since the *irritans* is found to predominate on floors of houses, a surface of wood was selected as the footing in our tests. In one experiment, five specimens were permitted to jump at will and the jumps of each were recorded. The mean average of ten jumps of each specimen gave a distance of 7 3–10 inches. The longest jump recorded was 11 inches; this was made by a female. In another experiment, a female, which was starved for five days prior to the test, made four jumps of respectively 10 5–10, 11, 12, and 13 inches; averaging 11 5–8 inches. Thirteen inches was the longest jump recorded on a horizontal plane. A jump of 15 7–8 inches was made downward at an angle of thirty degrees.

This specimen was then permitted to feed fifteen minutes on the arm of an attendant, after which it was carefully returned to the container, and its jumps for five minutes recorded. The longest jump after feeding was 12 inches.

The jumping powers of squirrel and rat fleas were tested in this manner: Three hundred and seventy-five live squirrel fleas (*C. acutus*) and one hundred and fifty live rat fleas (*C. fasciatus* and *L. cheopis*) were placed in two distinct lots in fifteen open specimen vials in a water bath and left undisturbed for two days. At the end of the period, the vials were examined, the water bath and the surroundings being carefully inspected. No fleas could be detected in the water bath or in the vicinity; the fleas in the vials were counted, the original number being present. They were apparently as active as when removed from their hosts. The containers were cylindrical vials 3 3–8 inches in height and 1 3–16 inches in diameter. The same test was tried in open shell vials of the next size smaller (3 1–8 x 1 inch) and the fleas were found jumping into the water bath.

L. cheopis, the rat flea, was tried for its jumping power. It had been previously observed that members of this species were unable to leap out of open shell vials 3 3–8 inches in height. It

was thought desirable to permit the flea greater latitude making the trial fairer and more practical. Twenty fleas (eight males and twelve females) were placed in a rectangular porcelain dish, the dimensions of which were 11 7-8 inches by 7 5-8 inches by $2\frac{1}{4}$ inches deep. A light sprinkling of moist sand was placed in the bottom of the dish to provide a firm footing and the sides of the dish were extended to the height of $4\frac{1}{2}$ inches, enclosing the container entirely by strips of "tangle-foot" paper. At the end of twenty-four hours the dish with the fleas was examined, and it was observed that several fleas had leaped high enough to become entangled on the adhesive paper. The position of these was noted, the distance from the bottom of the pan was measured. The entangled insects were pried off, the sticky material dissolved with alcohol and the insects examined microscopically. Five specimens were collected, two males and three females. The locations on the adhesive paper relative to the base of the dish were as follows:

1 F. $2\frac{1}{2}$ inches	1 F. 3 1-8 inches	1 F. 2 9-16 inches
	1 M. 2 5-8 inches	1 M. 3 1-16 inches

A census of the fleas remaining in the bottom of the dish gave 6 M. and 9 F. showing that none jumped over the surrounding paper, and that all jumping over $2\frac{1}{2}$ inches were embedded in the adhesive paper.

The jumping powers of *P. irritans* were further tested, twenty fleas of this species being placed in a rectangular museum jar, the inside dimensions of which were $2\frac{1}{4}$ x $5\frac{1}{2}$ x $7\frac{3}{4}$ inches depth. The glass lid of the jar was coated with "tangle-foot" and the sides of the jar within two inches of the top were likewise coated, with the same material. The following morning the jar was examined and two specimens were seen embedded in the "tangle-foot" on the lid. The inside height of the jar being $7\frac{3}{4}$ inches from the base gives then this height as the perpendicular jump.

Concerning the fleas ability to walk upwards on glass, we have noted that they cannot climb to any considerable distance. A great number of counts were made, the greatest distance observed being $\frac{3}{4}$ inches. The climb appears very laborious and in all cases the flea dropped to the bottom of the jar after a few efforts.

We have observed the manner in which these insects can find their way about upon their natural hosts. They pilot their paths among the dense hairs, walking on the flat of their tarsi, seeming to shuffle along. When on the animal they seldom hop about,

unless disturbed or unless the host snaps at them or scratches when unusually annoyed. They hop freely when jumping from the animal to the ground or vice versa, or from one host to another. When a flea is cornered, that is, when it experiences difficulty in passing an obstruction, it proceeds like a swimmer using the side stroke. The parasite drops to its side and locomotion ensues by a vigorous sweeping movement of the legs, almost entirely by the use of the hairs and spines, especially through the medium of the powerful spines of the tibia, when it ambles along on the flat side in a striking manner. The spines of the leg seem to be peculiarly adapted for this side motion: it is in this fashion that the nimble parasite manages to become so very elusive. We refer especially to the *P. irritans*. This may be tested by holding a live flea between the thumb and forefinger and unless you chance to be a flea trapper of long and painful experience the ingenious parasite will surely escape.

CONSIDERATION OF COLOR ATTRACTION.

We have a little experimental evidence on the question of attraction of these insects towards color in animals. It is the prevailing opinion that white animals attract the greatest number of fleas. We have to report a few tests of color attraction. The material used in the first experiment was six guinea pigs showing extreme variations of color: three of these were pure white and three pronouncedly dark. These were placed in a large cage, the bedding of which was infested with squirrel fleas. After forty-eight hours the guinea pigs were removed simultaneously and a census of the fleas on the individual animals was made immediately. Fleas and animals were anaesthetized at the same time, the white guinea pigs yielding respectively ten fleas, five fleas, and eleven fleas. The black guinea pigs yielded eleven, seven and four fleas; the last number came from a mixed black and white guinea pig. A summary of the fleas from the three white guinea pigs gave twenty-six fleas, or an average of about nine each; the two dark guinea gigs giving eighteen, averaging nine each, and the black and white giving four fleas, all of which were of the species, *C. acutus*, the squirrel flea.

A second experiment was as follows: Four guinea pigs were placed in a large container, which was swarming with squirrel fleas. After three days the animals were removed as before, and a census of the parasites was taken: one brown and black

guinea pig yielded eighty-nine fleas; another brown and black guinea pig yielded fifty-seven fleas; a pure white guinea pig yielded fifty-seven fleas; and the other white guinea pig yielded sixty fleas. These guinea pigs were kept together in the open vessel under the same conditions of light and temperature.

One experiment was conducted by using guinea pigs as traps for fleas in an infested house. The results shown are relatively meager due to the previous use of adhesive paper for flea trapping. In this test six guinea pigs were permitted to wander for twenty-four hours through the basement of the house. The fleas collected from the guinea pigs were *P. irritans* found on the hosts as follows:

Color of animal	Number of fleas
Black guinea pig	1
White guinea pig	1
Black guinea pig	1
White guinea pig	1
Black guinea pig	0
White guinea pig	0

It is obvious from these experiments that color does not exert the influence generally claimed for it. The white animals are no more attractive to the fleas we have used than are the dark colored ones.

TRAPPING OF FLEAS WITH MEAT AS A BAIT.

An idea prevails that fleas can be attracted and trapped on account of their predilection for the odor of fresh meat. This idea was put to test in an experimental way. On the 23rd day of August, 1909, during a season in the year in which fleas were extremely abundant, a vacant house, which was found to be flea infested, was chosen for the experiment. To give an idea of the abundance of the parasites, two attendants, who had occasion to enter the first floor of the dwelling, remained for the period of five minutes and emerged covered with fleas. Approximately two hundred fleas were taken from their clothing and persons. The materials used for the experiment were twelve sheets of "tangle-foot" fly paper, distributed in pairs among three rooms of the house. One sheet of each pair was supplied with a small fresh piece of cow's liver. Care was taken to distribute the sheets in such a manner that the influence of light would be the same for each pair of sheets in the series. The sticky fly papers were left undisturbed for a period of three days, then collected and examined.

A similar experiment was conducted at a later date, December 5th, 1909, when San Francisco dwellings were still flea infested. The sheets of fly paper were left in the basement of the house for twenty-four hours. The fleas in both experiments were removed by dissolving the "tangle-foot" in alcohol. The parasites which were all identified as *Pulex irritans*, were distributed on the sheets as follows:

Total number of fleas trapped.

	Experiment 1		Experiment 2	
Pair	Adhesive paper with meat	Adhesive paper without meat	Adhesive paper with meat	Adhesive paper without meat
1	0	0	2	4
2	2	2	1	3
3	2	1	6	4
4	0	3	47	49
5	6	12	1	0
6	4	1	4	1
Totals	14	19	61	61

The table shows that according to our experience, though the data is limited, meat used as a bait under the conditions stated does not exert any special attraction for fleas.

COPULATION AND EGG LAYING.

The most prolific of the rodent fleas, *Ceratophyllus acutus* was set aside for studies in mating. The fleas were observed in nature in relation to the host, then microscopically. For the purpose of close observation, a live ground squirrel (Citellus beecheyi) was placed in a mouse jar, where it was kept for a few hours under surveillance. It was noticed that when the animal's body was pressed against the glass that the pelage parted in furrows made by some active objects close to the skin. It was apparent that the squirrel was harboring a large number of active fleas, which occasionally came to view mounted on the hairs of the host.

The attention of the observer was attracted by a number of fleas which appeared gigantic in size. These proved on close inspection to be paired. Approximately 1 to every 3 of the total number of fleas infesting the squirrel appeared thus in copulation. The female of the pair covered almost entirely the body of the

male, which was quite lost to view, only the hind legs projecting beneath the abdomen of the female. The pair in copulation was observed never to feed, moving about as one insect; and anomalous as it appears, the member on the ventral side, the male, contributed no effort in the locomotion during the nuptial wanderings. His fore and middle legs doubled under the sternum, the hind pair extending stiffly as though paralyzed beneath the abdomen, where they were held securely by the tarsal spurs of the female interlocking with the tibial spines of the male.

The locomotory function was accomplished by the female, the front and middle legs of which were used freely in walking; by releasing temporarily the entwining spines of the hind legs she was able to leap at will. In this manner, the female moved about on the body of the host as though unhampered by its anchored mate.

Seven pairs of these fleas were collected from the live squirrel with the aid of a camel's hair brush, placed in cell slides and covered with glass slips. They were observed under the low power microscope, then kept in separate vials, one to several hours until the function was completed.

As observed microscopically, the male adheres to the female by the pseudo-joints of the terminal segment of the antennae. This attached appendage is extended and pendant, interlocking by its hairs the bristles on the ventral side of the second abdominal segment of the female. The hind femora of the latter grasps the male by the head at a point anterior to the antennal groove. The head of the male is held in position between the inner sides of the meta-femora of the female. The tarsal spurs of the female entangle the spines of the hind tibia of the male. The smaller of the pair thus suspended assumes the passive role moving at the volition of the female.

The copulatory act is manifested in the male by the watch-spring like action of the spiral, which, coiling and uncoiling intermittently extends and withdraws the terminal apparatus.

The male claspers are seen on either side of the vaginal groove of the female directly below the anal flap. The male makes a distinct concavity in the caudal portion of the back; with the strong action of the muscle attachments the plate of the penis is made very elastic. The spasmodic pulsations of the curled up abdomen are followed by a current of bubbles passing through the genitalia of the male upwards to the female. The spermatheca of the latter

is faintly discernible during the act as it swells and collapses. The length of time involving coition in the fleas under observation varied a trifle less than two hours to four and a half hours. The movements preliminary to the act were not noted.

The male makes the first effort to disconnect or disentangle the pair. In one instance, the male attempted to free itself by pressing vigorously the mid and hind tarsi against the hind tibia of its mate. Simultaneously, the antennae were torn from the recumbent spines of the abdominal segments of the female. The abdomen was straightened, relaxing the clutch of the claspers; the spiral contracted releasing the intromittent organ, and a final kick of the hind legs gave the male its liberty. The female was seen on ten distinct occasions to approach the male, and the latter repelled the advances of its larger companion; at each contact of the female, it would jump in the air, attempting to remain on the opposite side of the vial.

Mammalian blood appears essential for fleas to partake of normal functions of copulation and oviposition. In our experience insects kept constantly in jars and reared from cocoons never having been fed upon a host have not been observed to copulate or oviposit. In thirty specimens of *P. irritans* taken from a house which had been vacant for six weeks we found, after three days observation, that the fleas were perfectly healthy; and although females predominated no eggs were found at the end of this period. As a control, six females of this species collected from human hosts when kept in separate vials laid eggs normally, depositing from 5–12 in each instance.

Four experiments with *C. acutus*, the squirrel flea, have given results similar to the foregoing, namely, that this species when reared from cocoons and kept starved in jars at room temperature has not been observed to mate or lay eggs.

In twenty-five paired specimens of several species kept under observation it appears that the male does not long survive the act of mating. It dies even before the female has laid its first batch of eggs. When fertile females are kept under artificial conditions the eggs are laid in one laying in a period beginning two hours after copulation and extending to a maximum of thirty-six hours. When deprived of food the female has never been observed to oviposit after this length of time.

We may note here that when used experimentally the female is invariably longer lived. Experiments to determine length of

life with human blood diet show that female fleas of all species outlive the male by several weeks. This is doubtless true also under natural conditions, where we find in collecting fleas from the host that the females predominate markedly.

The eggs require optimum conditions of temperature and moisture for hatching. They have never been found on the host except in one instance. In this case a dog was used in the laboratory for supplying fresh fleas; this was done by placing the canine on sheets of paper which in a few hours were littered with a large number of flea eggs. These were laid loosely on the host by the fleas, the eggs falling to the paper, where they were collected. Flea eggs have never been found on man, and if present, would not hatch under normal conditions of the body temperature. We have found that keeping eggs in the incubator at blood heat is sufficient to prevent hatching. If the eggs were laid on the host we would certainly expect to find them on the squirrel, on which animal fleas are most abundant. We have taken from two squirrels, respectively, 225 *C. acutus* and 376 of the same species; but in no instance even where fleas are present in such large numbers have we been able to find eggs even after carefully combing the host. The *C. acutus* is by all means the best criterion in this matter, since we have found that it lays more eggs than any other of the rodent fleas.

The eggs are laid singly in small clusters, and may be viscous as in *P. irritans*, *C. fasciatus*, *L. cheopis*, *C. acutus;* or dry as in *C. canis* and *C. musculi*. The former adhere to the medium in which they are laid, and the eggs of the last two species are laid loosely, so that they roll when shaken in the vial containing them.

Eggs may be laid while the insect is still under the influence of an anaesthetic; when covered by a glass slip; and when exposed to strong sun light.

It appears to be the first impulse for the female to lay its eggs when removed from the host and placed under artificial conditions. The great majority of the eggs obtained were laid on the first day, beginning almost immediately after the fleas were captured. It is a common observation that many females with their abdomens distended lay their eggs as soon as the vial is closed over them. The number of eggs laid at one laying by different species, varies from 3 to 18; the rat fleas averaging 6 and the squirrel fleas lay as many as 18.

THE PROCESS OF HATCHING.

C. acutus.

Six eggs laid while the females were kept under observation were examined from time to time until hatched seven to nine days later. One egg, was observed microscopically during the entire process; the other five eggs used as controls were examined occasionally.

On the seventh day of incubation at room temperature the premonitory signs of hatching were discerned in a very faint rising and falling of the exochorion (outer shell layer) on one side of the shell. During the night, seven hours later, the movement grew more extensive, the pulsations becoming quite pronounced, causing the egg to shift slightly from its position. On the morning of the eighth day a deep gash was observed in the side of the egg. The gash is made by the egg opener, a wedge-shaped, horny, claw-like structure on the dorsal side back of the head of the embryo. This is operated so as to hew through the resistant shell by a series of slits or gashes. The initial gash increases slowly in length, encircling the egg within an hour.

In the course of a few hours, seven successive gashes are made, the location of these is quite constant; two on each side of the egg and three at the center, the middle of the latter being the most distinct. The young worm produces these slits through the chorion (inner skin of shell) by turning with its dorsal side against the shell, striking with the egg pick first against the base of the egg, rising on its hind prolegs and striking rapidly as it climbs upwards. Prior to each stroke the egg pick is poised deliberately, the weight of the head accelerating the blow; this is augmented occasionally by a lateral shaking of the head.

When the last slit encircles the shell, the embryo is at the most active stage, it effects a complete rotation in its shell at intervals of ten minutes. The gashes make the shell appear as though cut into ribbons. The rotary movement gradually subsides until a complete turning consumes twenty minutes, and almost imperceptibly there follows a lull. An inactive almost comatose condition prevails for a period of about seventeen hours. After the resting period, it appears that the egg pick is no longer functional; no new gashes are made, the embryo seeming contented to concentrate its energies against the middle gash.

This is enlarged by a puffing and dilating of the head; through the semitransparent shell is seen a constant bubbling and a subsequent dilatation of the cuticle.

On the third day of the hatching process, a strong movement of the embryo gives decided evidence of the progress of hatching. Immediately behind the egg pick, a triangular slit appears through which bubbles emerge to the surface of the exochorion; thus the amnion (the embryonic cuticle) makes its initial appearance through a crack in the exochorion of the shell.

The amnion splits longitudinally adhering to the chorion and bulging out as the insect struggles. It is pushed out of the chorion as the abdominal segments are projecting. The emergence is furthered by the young maggot pressing the head against its tail causing the middle of its body to bulge through the central gap of the shell. The amnion becomes noticeably darker as it is exposed to the air; it is now a light brownish-yellow.

The pressure of the body against the shell forms nearly a round hole through which the larva eventually emerges. The opening is enlarged by pressure of the head against the tail, raising the body like a hoop, causing an arch or a hump to appear with dorsal side outwards.

The amnion sheds slowly on either side from the middle of the arched abdomen ventrally and with a movement of fluid beneath it cracks across the abdomen, peeling and wrinkling as the segments telescope. With a final vigorous bubbling and wrinkling the amnion sheds off, the moulted skin falling on either side, exposing the quite colorless cuticle of the maggot roughly wrinkled and bristling with slender hairs. These hairs which at first appear transparent turn grayish when exposed to the air.

When the tail of the larva has been torn loose from the shell, the head and thorax are still imprisoned within the egg, necessitating a maneuvering by waving its tail in the air, twisting and squirming while standing on its head. The abdomen doubles up ventrally and finally the young larva supported on its tail extricates the head by a violent shaking. When the head is torn from its fastenings, it is found that the amnion has been holding it within the shell. The adhering membrane is cast out when the shell is shaken off. The larva has now fully emerged, the colorless cuticle has turned grayish and the slender threadlike bristles have assumed an iridescent hue.

The larvae upon hatching busy themselves immediately in the quest for food. They experience little difficulty in locating it, for at the time of birth a supply of food is found upon the egg shell. Here they feed from the first on the tiny blood pellicles surrounding the egg shell; this the mother furnishes when the egg is laid. When the last of the egg pellicles of blood are consumed, the insatiable worms look about them for other sustaining morsels. The dejecta of the adult flea seems to provide the desired ingredients. The young larvae feed ravenously on the bloody deposits, apparently satisfied to pass the first few days on this unique diet. They can subsist entirely on the bloody fragments (flea faeces) when no other food is available, for a period of five to six days.

THE REACTION TO LIGHT.

The larva is positively heliotropic up to the stage of the initial moult. The more advanced sluggish larvae are repelled by the light. This is seen when examining the flea breeding cages a slight stirring of the nesting material attracts to the surface the tiny very active larvae. If the older larvae are desired, it is found necessary to nearly invert the container. Prior to the final moult when the larva is in readiness to pupate it can be seen almost invariably along the edges at the bottom of the box, where the greatest number of cocoons are brought to view.

TROPIC INFLUENCES IN THE ADULT FLEAS.

Rodent fleas are negatively phototaxic (repelled by light) to a very striking degree. The first impulse seems to be to seek protection from the light. This is seen in combing a squirrel or rat recently killed; the fleas will retreat constantly to the underside, always in the direction away from the light. When shaken off, they return to the shadow of the host; in numerous instances even when the animal was dead for a period ranging from 24 to 50 hours the fleas when shaken off would seek the host and bury themselves under the hairs away from the light.

When a number of live squirrel fleas and rat fleas were placed in an open test tube and held horizontally with the operator's thumb covering the mouth of the vial and the bottom held against the window, the fleas crowded towards the open mouth in the direction of the thumb, bounding away from the window in an excited manner. When the tube was reversed with the open mouth towards the window, it was found unnecessary to

plug the mouth of the tube as the fleas did not attempt to jump out when given an opportunity to do so. Even when placed within a half inch of the open end of the tube with the head of the insect turned towards the light, the fleas reversed and jumped towards the closed end of the tube. This was repeated by tilting the mouth downward to offer an easier exit through the open mouth; but even this inducement did not influence the fleas, which invariably sought the closed end of the tube in the shadow. This was tried with squirrel and rat fleas as well as with human fleas and always with the same result.

LONGEVITY OF THE CALIFORNIA FLEA.

The great life of our native parasites seems to be anticipated at the very incubation. Eggs are laid at all times. We have observed oviposition during every month. The broods appear to be constant and the number irregular. The incubation stage of our Eastern forms taken from the observations of Pergande consumes 2–4 days ordinarily. Two days is given as the incubation period for the *cheopis* in India. Our experience with this species is a duration varying from 9 to 13 days at room temperature. When eggs of this species were subjected to identical conditions in which wild rats were caged in the laboratory basement (at a temperature of 20° to 25° C.) the length of the egg stage was 19 days.

Larval life is cited by Eastern and English authorities as a minimum of 8 days and a maximum of 24 days. The larval stage of our California fleas under laboratory conditions is never less than 28 days, often 30 days and sometimes longer.

Pergande found that the pupal or cocoon stage of the *Pulex irritans* varied from five to seven days in the summer months at Washington. Other authors working with this species give twelve days during summer months. We have observed several instances of cocoon life during the warm days of September. Thirty days appear to be spent in this stage.

The entire life cycle including adult life is given by several authors as four to six weeks. The British Indian Plague Commission gives as the time necessary for the completion of the cycle of development (in the case of *L. cheopis*) that is from the egg to the imago, as 21 to 22 days.

The following is given as a type of the life cycle observed in *C. acutus*. This specimen was kept under observation from the

moment the egg was laid by its parent. An hour after the egg was laid it was placed in a small vial with a little sawdust, sand, wheat grains and squirrel hair. It was allowed to develop in this environment until matured.

Stage of development	Date	Age of flea
Egg laid	May 4th, 1909	
Hatched	May 12th, 1909	8 days
Moulted (second stage)	May 18th, 1909	14 days
Moulted (third stage)	May 28th, 1909	24 days
Cocoon	June 9th, 1909	36 days
Adult	July 10, 1909	67 days
Alive (never having been fed)	Aug. 11, 1900	99 days

The English workers in India ascertain the length of time which adult fleas live on rats as 41 days. The longest life of this species on an exclusive diet of human blood was observed to be 27 days. We have managed to keep this species (*cheopis*) alive for a period of 36 days by feeding on man. The length of life without feeding was also noted. This period varied in the experiments of the English Commission according to the environments in which the fleas were maintained. In the absence of liquid food supply, fleas could live in bran for six days, in gunny sacking a similar time, and in sand with moist cowdung for 13 days. From onr observations we have found the majority of fleas of all species to die in five days unless a moist medium was provided.

As we have stated above rat and squirrel fleas may be kept alive for a considerable time when moisture is provided in some form. It is interesting to note that fleas which have never tasted animal food, having emerged from the cocoon and kept under the same conditions in similar material as fleas taken directly from the host, will prove longer lived. A number of specimens of *Ceratophyllus acutus* removed from a ground squirrel and kept in moistened wheat grains and sawdust lived for 26 days. An equal number of fleas of the same species bred from cocoons in the laboratory were kept without a host in a similar medium. One male lived 38 days and a female lived for 65 days.

In a series of experiments in which fleas taken from healthy rats and squirrels were fed daily on the arm of a man we attempted to determine the maximum longevity of these parasites. The fleas were placed individually in open test tubes and at feeding time the tubes were inverted over the arm of one of the laboratory attendants. Fleas were thus applied daily for a period of from 5 to 15 minutes, but only the actual feeding time was recorded. The average was about five minutes.

A *Loemopsylla cheopis* was fed for 35 days, escaping on the 36th day. One *C. acutus* died after 58 days and another one at the end of 51 days. The common brown rat flea *C. fasciatus*, proved to be the most persistent feeder of them all. Unfortunately one of them was permitted to escape after feeding on its induced host for 63 days. Another of the group suffered no ill effects from its enforced diet for 98 days; and the sole survivor had been nourished by its foster host since its removal from the rodent host for a period of five months. The experiment was discontinued, but the parasite survived a week longer in a starved condition.

LONGEVITY RELATIVE TO SEX.

We have noted the relative longevity of the sexes under the conditions of experiments in which fleas were fed on human blood alone.

We shall take for consideration the two species common to rats, *L. cheopis* and *C. fasciatus* and the predominant squirrel flea, *C. acutus*. Four tests with *C. fasciatus* gave the following data:

C. fasciatus.

Six males of this species averaged 8½ days, the maximum life being 17 days. Fifteen females gave an average of 32 4-5 days with a maximum of 125 days. The two unfed controls (male) of this series lived for 3 days, and the two control females lived for 5 days.

L. cheopis.

Two tests with a total of seven males of this species gave an average of 10 1-7 days and a maximum period of 15 days.

Three females lived 28 1-3 days as an average and a maximum period of 49 days.

The two unfed male controls lived 5 days and in four females the average was 5½ days and the maximum 7 days.

C. acutus.

One test with this species furnishes the following data: Three males averaged 11 days, and gave a maximum of 11 days.

Five females averaged 15 1-5 days. The longest life was 53 days.

The unfed males averaged 3 days and showed a maximum of 4 days. The female control lived 5 days.

The greatest length of life of a male of any species is seen to be 17 days; and the term of life under these conditions for a female was 125 days, somewhat over 4 months.

In these tests for longevity, it should be borne in mind that no attempt is made to arrive at the initial age of the fleas, but the time is reckoned from the day of removal from the host.

An effort was made to determine the length of adult life of one species, *C. acutus*, by feeding the insect newly emerged from the cocoon. Ten specimens emerging within a few hours of each other were fed on the same day on human blood. One specimen, a female, lived for sixty-four days; at which time the experiment was discontinued. The unfed controls, as well as the specimens given a human blood diet, were kept in ordinary test tubes at room temperature. The activities of these fleas may have been influenced by changes in the temperature and the absence of moisture in the tubes.

NOTES ON THE FEEDING PROCESS.

There is a remarkable degree of variation in the feeding habits of the different species of fleas. We have not attempted except in a superficial way, to study the idiocyncracies of the rodent fleas in regard to the biting of their normal hosts. We have, however, quite thoroughly observed the manner of biting under experimental condition with man as a host. Without taking into account the attraction or repulsion which may be exerted towards man as a host, we shall consider the more striking features of the biting of the parasites. We find that the species do not all attack with equal avidity. *Pulex irritans* the ectoparasite of man, is insatiable in its blood craving. It differs in its relation to man in being more fastidious in its feeding than the rodent fleas. Although its bite is painful, it does not voluntarily feed in one spot for any great length of time. The *Pulex irritans* differs from all other species (hundreds of specimens of which were tested on human hosts) in that it squirts blood per anum during the act of biting.

The *L. cheopis* and *C. fasciatus*, the normal rat parasites, are found to bite man with equal readiness and will live about the same length of time when fed on human blood. Their biting is well defined and effective, but not nearly so painful as that of *Pulex irritans*, nor so prolonged as the common squirrel flea, *Ceratophyllus acutus*. A specimen of *C. acutus* when starved for

several days has been observed to feed on man uninterruptedly for a period of nearly one hour (59 minutes) at one insertion of its proboscis.

The bite of the *Ctenopsyllus musculi*, the blind flea of the mouse, is the feeblest we have had inflicted from any flea tested. The short weak piercing organs of this species makes a puncture, which is scarcely perceptible. In observing the length of time this flea bites, it is necessary to depend as a guide on the distention of the abdomen with blood rather than the prick of the mandibles. The *musculi* seems not able to adapt itself as an induced parasite of man. From a few experiments it appears to live not longer than five days on a human host.

The *Ceratopyyllus acutus* which proves a very ready parasite of man makes its attack even without inducing experimentally. Our data compiled from reports and collections of squirrel hunters shows that this species, as well as the other common squirrel flea, *Hoplopsyllus anomalus*, will bite man when exposed to their attacks.

The unusually long rostrum in this flea is presumed to be the cause of its prolonged feeding at one insertion of the mouth parts. This principal is not unprecedented judging from a study of numerous parasites in the insect world.

The following is the description of the method of feeding observed in *C. acutus*. This method is typical.

The flea when permitted to walk freely on the arm selects in a few minutes a suitable hairy space where it ceases abruptly in its locomotion, takes a firm hold, with the tarsi, projects its proboscis and prepares to puncture the skin.

A puncture is drilled by the pricking epipharynx, the saw-tooth mandibles supplementing the movement by lacerating the cavity formed. The two organs of the rostrum work alternately, the middle piece boring, while the two lateral elements execute a sawing movement. The mandibles, owing to their basal attachments are, as is expressed by the Journal of Hygiene, Vol. 6, No. 4, p. 499, "capable of independent action, sliding up and down but maintaining their relative positions and preserving the lumen of the aspiratory channel." The labium doubles back, the V-shaped groove of this organ guiding the mandibles on either side.

The action of the proboscis is executed with a forward movement of the head and a lateral and downward thrust of the entire body. As the mouth parts are sharply inserted, the

abdomen rises simultaneously. The head and middle legs are elevated resembling oars. The fore legs are doubled under the thorax, the tibia and tarsi resting firmly on the epidermis serve as a support for the body during feeding. The maxillary palpi are retracted beneath the head and thorax. The labium continues to bend, at first acting as a sheath for the sawing mandibles, and as these are more deeply inserted, it bends beneath the head with the elasticity of a bow, forcing the mandibles into the wound until the maxillae are embedded in the skin of the victim. When the proboscis is fully inserted, the abdomen ceases for a time its lateral swinging.

The acute pain of biting is first felt when the mandibles have not quite penetrated and subsequently, during each distinct movement of the abdomen. The swinging of the abdomen gradually ceases as it becomes filled with blood. The sting of the biting becomes gradually duller and less sensitive as feeding progresses. The movements of the elevated abdomen grow noticeably feebler as the downward thrusts of the springy bow-like labium become less frequent.

As the feeding process advances, one can discern through the translucent walls of the abdomen, a constant flow of blood, caudally from the pharynx, accompanied by a peristaltic movement.

The end of the meal is signified in an abrupt manner. The flea shakes its entire body, gradually withdraws its proboscis by lowering the abdomen and legs, and violently twisting the head.

When starved for several days, the feeding of the rat fleas is conducted in a rather vigorous manner. As soon as the proboscis is buried to full length, the abdomen is raised and there ensues a gradual lateral swaying motion, increasing the altitude of the raised end of the abdomen until it assumes the perpendicular. The flea is observed at this point to gain a better foothold by advancing the fore tarsi, and, then gradually doubling back the abdomen, it turns a back spring, with extreme agility, nearly touching with its dorsal side the skin of the hand upon which it is feeding. Meanwhile, the hungry parasite feeds ravenously.

It is interesting to note the peculiar nervous action which the rodent fleas exhibit immediately when the feeding process is completed, or when disturbed during the biting. Even while the rostrum is inserted to the fullest, the parasite shakes its head spasmodically, in a twinkling the mouth is withdrawn and the flea hops away.

POSSIBLE VITAL CONSIDERATIONS INVOLVED IN FEEDING HABITS.

We have previously noted that rodent fleas can live in a starved condition, away from the host, during a period of three to ten days, when kept in dry test tubes; as long as twenty-eight days when a suitable moist medium is furnished. The long periods of starvation appear not to affect the vitality of the parasite to such an extent that the ability to feed is impaired. We have recorded instances in which a specimen of the squirrel flea *H. anomalus* starved for sixteen days, and several specimens of *C. acutus* starved for twenty-seven days had sufficient energy to feed 10–15 minutes when an arm was placed in the breeding jar. These facts lead us with others to accredit in a measure the claims of older authorities on plague, who contended before the flea theory was recognized, that clothes and baggage of an infected community harbored the germs of plague, which remain viable during long period of time. Modern writers have called our attention to the plausibility of infection in clothes and baggage due to the agency of fleas, which may be transported from infected communities. Bannerman (Journal of Hygiene, Vol. 6, 1906, pp. 189–191), writing on the possibility of the spread of infection by means of clothes, brings forth several instances in which conveyance of infection by clothes seemed the most likely means of introduction of plague in some villages in India. Plague infected rat fleas secreted in the clothes en route are held responsible for the transmission. Bannerman cites an instance of plague transmission through clothing where as much as ten days elapsed in the transportation of clothing removed from a plague infected victim and worn by a relative of the deceased, who in turn contracted the disease.

It has not been our intention to enter into a discussion of the flea from the standpoint of plague epidemiology; it is desired merely to indicate the possibility that starvation of infected fleas may not eliminate the danger of transmission. The presence of plague bacilli in rodent fleas as pointed out by the English Plague Commission (Journal of Hygiene, Vol. VIII, p. 261) does not appear to affect the rate of mortality in these insects.

SUMMARY OF RESULTS.

1. The breeding of fleas under laboratory conditions can be carried on quite satisfactorily when there is furnished a medium simulating the nest of the host. It will be seen that fleas taken from the natural host can be kept alive without food for a considerable time, providing the proper moisture conditions are maintained. A medium of moist sawdust with a few grains of wheat prolonged the life of these insects to twenty-six days. Those without this medium under the same conditions, died on the seventh day.

2. Rat fleas namely, *L. cheopis*, *C. fasciatus* can not jump higher than 3 1–8 inches.

P. irritans, the human flea, was found to make a perpendicular jump of 7 3–4 inches and as far as 13 inches on a horizontal plane.

3. Experiments with black and white guinea pigs show that in relation to color attraction white animals are no more attractive to the fleas than are the dark colored ones.

4. Experiments with adhesive paper baited with meat, demonstrate that fleas can not be trapped by the odor of meat.

5. In the mating of fleas, the female takes the initiative and the male assumes the passive role.

6. Fleas reared from the cocoon kept without a host have never been observed to copulate or oviposit.

7. The eggs are never laid on the host. Oviposition takes place within thirty-six hours after the female is removed from the host.

8. The process of hatching consumes a period of 3–4 days. The embryo breaks through the shell by means of a special egg pick, which is instrumental in the emergence.

9. The larvae can live on the bloody egg pellicles and the dejecta of the parent for a period of 5–6 days.

10. The larvae are positively heliotropic in the early stages and repelled by light in the later stages.

11. Adult fleas are negatively phototaxic.

12. The California rodent fleas have a greater life in all stages than fleas of the Eastern United States and India. The

average length of the stages of development, in *C. acutus* as a type, are as follows:

Egg stage	8 days
Larval stage	28 days
Cocoon	31 days
Adult without host	32 days and longer

13. Fleas which have never been fed from the time of emergence from the cocoon prove longer lived when starved than fleas removed from the host.

14. Rat fleas may be kept alive on a human host for a considerable time, one specimen being kept alive as long as five months.

15. The females of all species of fleas are considerably longer lived than the males.

16. Induced parasitism of rodent fleas on man seems to be influenced by the length of mouth parts in the different species. One specimen of *C. acutus*, the species with the longest rostrum, fed for a period of nearly one hour at one insertion of the mouth.

17. It is indicated that starvation of infected fleas, when these insects are transported in clothing, may not eliminate the danger of transmission of plague.

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A STUDY ON THE STRUCTURE OF THE EGG OF THE WALKING-STICK, DIAPHEROMERA FEMORATA SAY; AND THE BIOLOGICAL SIGNIFCANCE OF THE RESEMBLANCE OF PHASMID EGGS TO SEEDS.*

HENRY H. P. SEVERIN, University of Wisconsin.
(With Plate IX.)

A detailed description of the eggs of the walking-stick is essential because in the systematic work on the Phasmidae, the eggs are said to be a very valuable auxiliary means of identification, since their form, "für die Genera charakteristisch ist." (Brunner von Wattenwyl†). Kaup (8) even remarks, "Vielleicht wird man später die Arten durch die Eier schneller unterscheiden lernen als durch die Thiere selbst!"

Measurements of Eggs: Heymons (6) found with Bacillus rossi that the size of the eggs is not constant. "Es sind mir Eier zugekommen, wahrscheinlich die letzten, welche das Weibchen abgesetzt hat, die höchstens die Hälfte der üblichen Grösse besassen, trotzdem waren sie aber normal gebaut und es sind aus ihnen ebenfalls Larven ausgeschlüpft." In Diapheromera femorata a considerable variability in the dimensions of the eggs is also present but the smaller eggs were not necessarily the last ones which the female lays,—they may appear among the first or at any time during the egg-laying.

The size of the eggs varies between the following dimensions:

Length.................................20–29 mm.
Depth, from dorsal to ventral surface........11–18 mm.
Width or thickness from side to side.......... 9–14 mm.

* Submitted as a part fulfillment of the thesis requirements for the degree of Ph. D. at the University of Wisconsin.

† Paper not accessible. Quoted from v. Brunn's (2) paper.

The majority of eggs varied between the following dimensions:

Length	25–29 mm.
Depth	15–17 mm.
Width	12–13 mm.

Shape and Color of Egg: The eggs resemble very small beans with some variation in shape; some are ellipsoid, others ovoid and still others nearly spherical in form. Their color is usually a glossy black, except on the slightly more convex side which is white; instead of the black, however, there may be light shades of gray or light chocolate-brown. Out of a thousand eggs, twelve showed the light shades of gray and only three, the light chocolate-brown color.

When the operculum is removed the egg, in this region, is obliquely truncate and surrounded by an elliptical or oval rim. On the inner margin of this rim rested the operculum. The rim is provided with a circle of yellow, chitinous, bristle-like projections. In most eggs the white color of the slightly more convex side is continued around the base of the rim as a white line.

Operculum: The operculum (Fig. 1, *op*) fits perfectly within the rim of the egg capsule (Fig. 1, *ri*) and is usually set free when the egg is broken. If the operculum is cleared, mounted and examined under the microscope a ragged membrane is discernible at its margin (Fig. 3, *vi*). This is the torn, so-called "shell membrane" to which the operculum was attached.

Sharp (16) who has described a number of Phasmid eggs, has probably overlooked the fact, that the operculum is attached to the so-called "shell membrane." He writes, the operculum "is present in all known eggs of the Phasmidae; it is a lid that fits very accurately to the truncate anterior extremity of the egg; its margin is surrounded by a margin of the capsule, and it is owing to the perfect fit between the two that the operculum retains its position." Müller (13), however, in the case of *Phasma ferula* claims that, "Am Rande des Ausschnitts springt die innere Schalenhaut etwas vor, ein Rudiment der Verbindung der Schale mit dem Deckelchen. Die innere Haut des Deckelchens und die innere Haut der Schale sind also an dem unverletzten Ei ein Continuum." Leuckart (10) who has worked on the structure of the eggs of two species of Phasmids belonging to different genera also finds that, "Durch Hülfe dieser Schalenhaut wird der Deckel, der sonst vollkommen isolirt ist, in seiner Lage erhalten und befestigt."

A number of zoologists who have worked on the structure of the eggs of the Phasmidae claim that a "shell membrane" exists within the inner surface of the chorion. Müller (13) writes, "Die innere Fläche der Schale wird von einer sehr dünnen häutigen Lamella, *der Schalenhaut*, überkleidet, die sich nur in kurzen Stücken von der Schale selbst wegnehmen lässt." Leuckart (10) agrees with Müller that a "shell membrane" lines the inner surface of the chorion. "Dazu kommt als Bekleidung der innern Chorion-fläche noch eine eigne dünne 'Schalenhaut,' die schon von J. Müller aufgefunden ist, also wahrscheinlich unter den Phasmoden eine ziemlich allgemeine Verbreitung hat, obgleich sie den übrigen Insekteneiern abgeht." In the eggs of Diapheromera femorata the so-called "shell membrane" is the innermost layer of the chorion, which peels off in small fragments in the eggs that are in the early stages of development, but in the later stages, as Leuckart (10) has observed, "Bei *Cyphocrania* lässt sich diese Haut ohne grosse Schwierigkeiten in continuo abheben —bis auf die Narbe, an der dieselbe fest mit dem Chorion verwachsen ist und ein weisses Aussehen hat." To Leuckart's observation may be added, in the case of the eggs of Diapheromera femorata, that a firm attachment also exists at the rim between the so-called "shell membrane" and the next outer layer of the chorion.

A microscopical examination of the operculum from the outer surface shows a resemblance to the framework of a dome, which is shut off at the base by a slightly concave floor of chitin. The framework consists of brownish, irregularly-flattened, chitinous rods. All of these rods arise from an elliptical or oval brownish rim of chitin (Fig. 3, *br*) which is in continuation with the similarly colored upper surface of the floor of the dome (Fig. 4, *e*). Some of the rods anastomose, enclosing a large, more or less, central space at the top of the dome (Fig. 3, *c*) and a varying number of irregular areas (Fig. 3, *d*) which are not constant in number in the different opercula. Those rods which do not extend to the top of the dome project free into the irregular spaces (Fig. 3, *p*).

Various authors have called attention, in different Phasmidae, to the resemblance in the histological structure of the egg capsule to the structure of certain plant tissue. Murray (14) finds, "a most striking resemblance to a piece of honey comb" in the structure of the egg capsule of *Phyllium Scythe*. Accord-

ing to Joly (7) who has worked on the structure of the egg of *Phyllium crurifolium* "ce tissu présente la plus grande analogie avec celui du liège, c'est-à-dire qu'il est formé de cellules irrégulières (carrées, pentagonales, sexagonales) très petites et très serrées. La couche extérieure qui recouvre cette coque, est beaucoup plus épaisse et, comme nous l'avons dit, elle ressemble à l'ecorce rugueuse du Chêne-liège, dont elle a la légèreté. Nouvelle et curieuse analogie de notre insecte avec le règne végétal: analogie qui devient plus complète encore, quand on songe que l'oeuf du *Phyllium* est muni d'un opercule qui s'ouvre lors de l'éclosion, à la manière d'une pyxide." Brongniart* who has examined the eggs of Phyllium pulchrifolium also compares the external envelope to that of cork. According to Henneguy (5) who has also worked on the histological structure of the egg-capsule of Phyllium crurifolium, "L'ensemble de la couche externe présente une grande analogie de structure avec la partie libérienne d'une écorce de dicotylédone traversée par les rayons médullaires."

A cross section through the operculum of the egg of Diapheromera femorata shows that the space between the floor and top of the dome is partially filled with chitinous deposits, which, according to a vegetable histologist, resembles somewhat the thin walled parenchyma of plant tissue, except that no middle lamella was discernible (Fig. 4, *a*). Müller (13) describes the chitinous deposition as "ein zelliges Gewebe aus deutlich sechseckigen oben offenen Zellen bilden. Dies scheint einer besonderen Beachtung werth, da die Ercheinung eines regelmässigen zelligen Gewebes in der Organisationsstufe der Insecten gewiss die seltenste ist." It would be rash to speculate as to the formation of this chitinous deposition since the manner in which the operculum is formed is obscure. Sharp (16) suggests two methods: "first, autotomy of the pole of the egg; second, adhesion of the mass of matter from the adjacent nutrient chamber, to form as it were a very imperfect second egg."

"*Hilar area, cicatricula or Narbe*" of *Egg:* On the outer surface of the exochorion, of the slightly more convex side of the egg is an elliptical region resembling somewhat the hilum of a seed. Sharp (16) calls this region the "hilar area," Müller (13) the "cicatricula" or "Narbe," Leuckart (10) and Heymons (6) also use the term "Narbe." The margin of this "hilar area"

* Paper not accessible. Quoted from Henneguy's (5) paper.

is slightly elevated and buff-colored (Figs. 1 and 8, *m*). At the posterior end, this margin narrows enclosing a semicircle (Figs. 1 and 8, *s*) within which lies the micropylar orifice (Figs. 1 and 8, *o*). The margin of this semi-circular area is in continuation with a ridge which extends towards the posterior pole of the egg. The buff-colored ridge joins a triangular extension of the black region of the egg (Fig. 1, *r*) and gradually disappears as it passes posteriorly into the surrounding black surface. Within the slightly elevated buff-colored margin is a white convex region which terminates at the posterior end in the microypylar orifice, where the white color gives way to black (Figs. 1 and 8, *o*).

Mycropylar Apparatus: Müller (13) did not understand how eggs of insects with a hard chorion were fertilized and he takes an extreme view as to the way this phenomenon takes place in the eggs of the Phasmidae. "Bei den *Phasmen* hat die Samenkapsel ausser ihrer einen Oeffnung nach aussen keinen besondern Ausführungsgang. Aber der Eingang der zweihörnigen Samenkapsel liegt gerade über dem länglichen Ausgang des Eiergangs. Der Samen tritt also aus der Eingangsöffnung der Kapsel unmittelbar in der Mündung des Eierganges ein, um sofort zu den Eierleitern und Trompeten zu gelangen."

"Wir haben aber bewiesen, das eine Befruchtung der Phasmeneier nicht anders, als vor ihrer Ausbildung und namentlich vor der Ausbildung der Schale, möglich sey."

The micropylar apparatus is very remarkable and differs from any of those which Leuckart (10) has described for so many insect eggs. As already mentioned the micropylar orifice is found at the posterior end of the convex area, just within the space enclosed by the semicircular chitinous thickening of the margin. This opening leads into a small canal, the micropylar canal, which passes a short distance towards the anterior pole of the egg. The micropylar canal is elliptical in cross section and surrounded by extremely thick chitin (Fig. 5, *g*). When the inner surface of the "hilar area" in the region of the micropylar apparatus is examined under a microscope, an invagination of the inner surface of the chorion is readily seen; at the bottom of this inpushing is the opening of the micropylar canal (Figs. 6 and 8, *i*). If the vitelline membrane in this region is now examined under a binocular, one finds that a small, obliquely-inclined, membranous tube has been torn away from the opening of the canal (Fig. 2, *t*). A glance at Fig. 7, *v*, shows the opening

of this membranous tube, the vitelline membrane micropyle, into the vitelline membrane. The sperm thus enters the micropylar orifice, passes through the micropylar canal, then through the membranous tube and out of the vitelline membrane mycropyle to reach the egg.

Müller's (13) supposition that the sperm passes from the seminal receptacle, through the common oviduct, then into the oviducts to the ovarian tubule and fertilizes the egg before the chorion is formed is entirely erroneous. Leuckart (10) from observations on Gomphocerus found that the micropyles, "nicht von Anfang an dem Chorion zukommen, sondern erst nach der Ablagerung desselben durch Resorption ihren Ursprung nehmen * * * * . Eine Bestätigung dieser Beobachtung finde ich darin, dass ich nicht selten (wie u. a. bie Borborus, Tetanocera und verwandten Fliegen) Eierstockseier antraf, deren Micropylapparat noch ohen Oeffnung war, sonst aber bereits vollkommen entwickelt schien."

"Vor der Ablagerung des Chorions habe ich an der Dotterhaut niemals eine Micropyle wahrgenommen * * * * . Wohl aber habe ich Fälle beobachtet, in denen bei Anwesenheit der Chorionmicropyle die Dotterhaut noch ohne Loch zu sein schien." In all probability the eggs of the walking-stick are fertilized as they pass below the opening of the seminal receptacle.

The Biological Significance of the Resemblance of the Phasmid Eggs to Seeds: A number of naturalists have called attention to the striking resemblance of the Phasmid egg to a seed. In some cases, the egg resembles the seed of the natural food plant of the insect.

In seventeen species of Phasmids obtained from Lifu and New Britan, Sharp (16) has described the eggs of a number of these. In regard to the resemblance of the eggs to seeds he writes: "The climax of the peculiarities is found in the extremely perfect structure of their eggs and the resemblance of these eggs to seeds. The egg of the Phasmid has not only a general resemblance in size, shape, colour, and external texture to a seed, but the anatomical characters of certain seeds are reproduced on the external surface, there being a hilar area, a hilar scar, and a capitulum corresponding to the micropylar caruncle of such seeds as those of the Castor-oil plant (Ricinus communis). The hilar area on the inner surface of the capsule is, in shape, like the embryo of a plant. Moreover, naturalists who have examined these eggs

declare that the minute structure of this curious egg-capsule cannot be distinguished histologically from plant-structure."

Among the leaf-insects the resemblance of the eggs to seeds is especially marked. Nab* as early as 1854 has compared the egg of one of these leaf-insects to the seed of the "Belle-de-Nuit (*Mirabilis Jalapa*)." Henneguy (5) in the case of the egg of Phyllium crurifolium claims that, "Sa forme est celle d'un akène d'Ombellifère, et représente, par example, la moitié d'un jeune diakène de *Conium maculatum*. L'oeuf diffère de l'akène d'Ombellifère en ce que son opercule régulièrement conique, est situé au centre de sa face supérieure, tandis que le style conoïde de l'akène est aplati sur la face commissurale." Morton (12) in this same species writes that the "egg has been confused with a seed of Mirabilis and Coniom!"

According to Stockhard (18) the walking-stick, Aplopus mayeri, is found only on its food plant, *Suriana maritima*. "While one may find a close resemblance in size and color between the eggs of *Aplopus* and the seed of *Suriana*, both of which fall from the branches to the ground, where they are obscured among the débris" yet the eggs differ from the seeds considerably in shape.

The eggs of Diapheromera femorata were shown to a number of botanists, and with one exception, all mistook them for seeds. The botanist who did not fall into this error broke the egg before giving his opinion. When asked as to what seed the egg resembled all failed to recall any particular one. A leguminous seed, such as a small bean, was suggested, but none could be found in the natural habitat of Diapheromera, that resembled its egg in size and color.

If these botanists are unable to distinguish the egg of a walking-stick from a seed, can a grain-eating bird distinguish between the two? If a bird were to feed on the seeds of the Suriana maritima which resemble the eggs of Aplopus mayeri in size and color, could the bird discriminate between the two, on account of a difference in shape?

Goldi (4) in the case of the eggs of two Brazilian walking-sticks raises the question as to how far this imitation is useful in the protection of these eggs. Grain-eating birds may eat the egg but general insectivorous birds would probably mistake it for a seed and leave it untouched. The protective dress of the

* Quoted from Henneguy's (5) paper.

egg may be only a relative protection in which new dangers are involved. He next raises the argument that these eggs on account of the resemblance to some Brazilian seeds, deceive, so he believes, the egg-parasites.

This would imply that through the sense of sight the egg-parasite would overlook the eggs on account of their resemblance to some Brazilian seeds. It is open to serious question whether the egg-parasites are guided to the eggs of their host through the sense of sight alone, if at all. One illustration will suffice. We (15) have found that Trichogramma pretiosa parasitizes the eggs of Cimbex americana, and yet the egg-parasite cannot see the eggs of its hosts as Cimbex deposits its eggs in a receptacle within a willow leaf. In all probability, the sense of smell plays an important role in guiding the egg-parasites to the eggs of their hosts.

A careful survey of the literature shows that the eggs of Phasmids are subjected to the attack of a number of enemies. According to King (9) the eggs of Anisomorpha buprestoides "are victimized in a similar manner by a minute species of Ichneumon fly, one of which has fortunately been obtained; it is probably one of the Chalcididae: all the transformations take place within the egg, and when fully developed the perfect Ichneumon fly emerges therefrom."

Bates (1) "observed that the author of the note was probably in error in attributing the name of Anisomorpha buprestoides to the species in question, which seemed to be a true Phasma."

Smith (17) "remarked upon the peculiarity of all the transformations of the Chalcidite parasite taking place within the egg of the Phasma; such a mode of development was novel, if true, but he suspected some error of observation."

M'Lachlan (11) "suggested that the cocoon of the Chalcis had been mistaken for the egg of the Phasma."

von Brunn (2) records the observation of Wolff von Wülfing, that the young larvae as well as the eggs have many enemies, "hauptsächlich Springspinnen und Hauseidechsen."

Girault (3) in his paper on the "Hosts of the Insect Egg-Parasites in North and South America" does not record an egg-parasite from any Phasmid.

I think that the resemblance of the eggs to seeds has no biological significance as a means of protection against the egg-parasites, if the eggs of the Phasmidae are parasitized. Sharp (16)

in all the species which he has examined believes that these resemblances in the eggs have no bionomic importance for the species and I am strongly inclined to accept his view in the case of the egg of Diapheromera femorata.

I am indebted to my teacher and friend, Prof. Wm. S. Marshall, for many valuable suggestions in this work and the more than ordinary courtesies extended to me in the use of his excellent entomological library.

Zoological Laboratory, University of Wisconsin, Madison, February 1, 1910.

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Explanation of Plate IX.

All figures were drawn with a camera lucida.

Fig. 1. "Hilar area" on the slightly more convex side of the egg: *op*, operculum; *r:*, rim in which the operculum fits perfectly; *m*, margin of the "hilar area"; *s*, semicircular margin; *r*, buff-colored ridge which passes over into the triangular extension of the black region of the egg; *o*, micropylar orifice.

Fig. 2. Vitelline membrane of egg, after the chorion of the "hilar area" has been removed: *t*, membranous tube, which connects with the opening of the micropylar canal on the inner surface of the chorion.

Fig. 3. Operculum from the outer surface: *vi*. torn so-called "shell membrane" to which the operculum was attached; *br*. brownish rim of chitin from which the irregularly-flattened chitinous rods arise; *c*, large, more or less, central space at the top of the operculum enclosed by the anastomosing rods; *d*, irregular areas which are not constant in number in the different opercula; *p*, rods which project free into these irregular spaces.

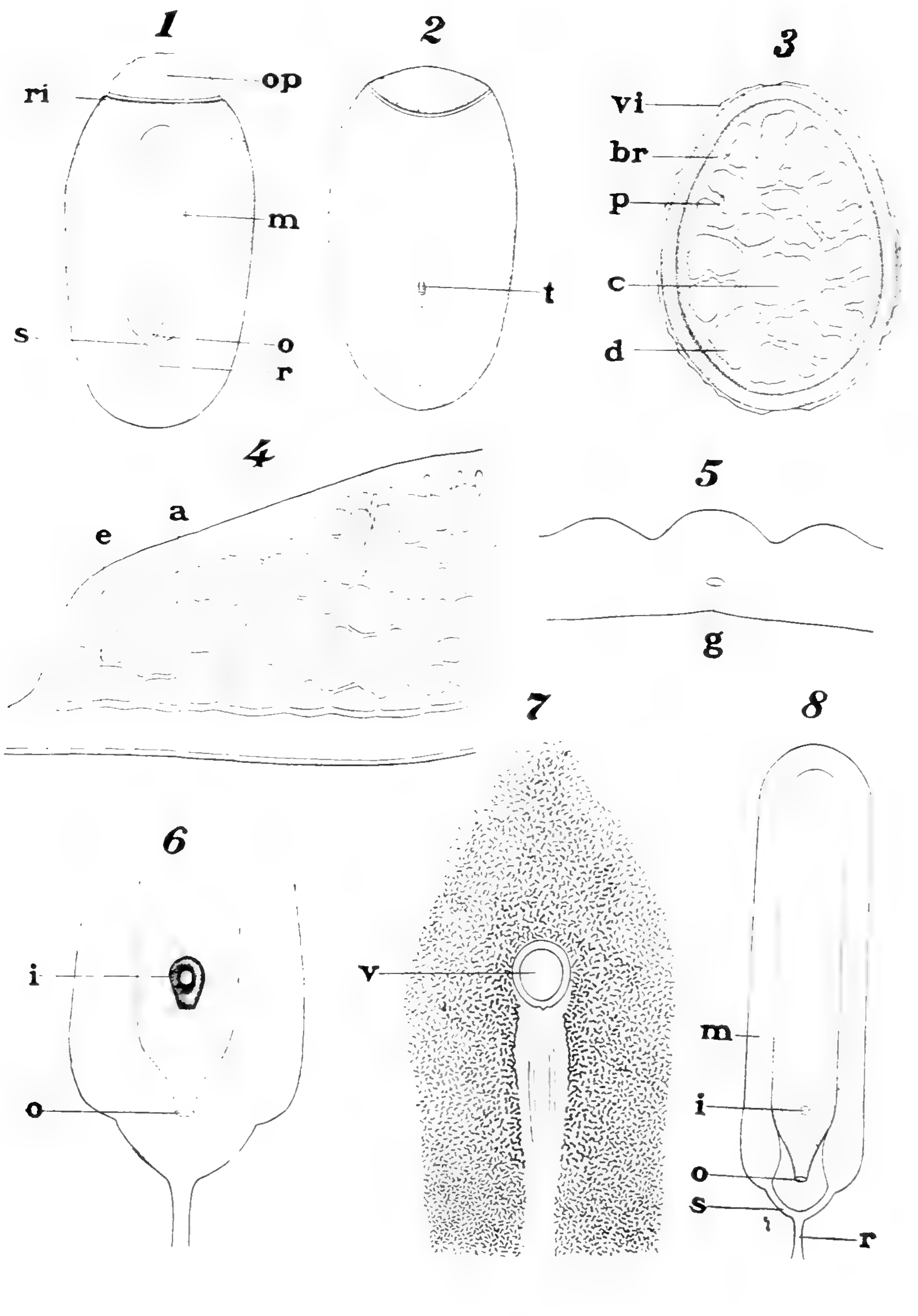
Fig. 4. Cross section of a part of the operculum: *c*. brownish upper surface of the floor of the operculum; *a*, chitinous deposits, between the floor and top of the operculum, resembling somewhat the thin-walled parenchyma of plant tissue except that no middle lamella is discernible.

Fig. 5. Cross section of the micropylar canal *g*, which is surrounded by extremely thick chitin. This canal opens to the exterior by the micropylar orifice.

Fig. 6. Posterior region of the inner surface of the "hilar area" of the chorion: *i*, opening of the micropylar canal in an invagination of the inner surface of the chorion; *o*, micropylar orifice.

Fig. 7. Vitelline membrane in the region of the micropylar apparatus: *v*. opening of the membranous tube, the vitelline membrane micropyle, into the vitelline membrane.

Fig. 8. "Hilar area" on the outer surface of the exochorion; lettering as in Figs. 1 and 6.



H. H. P. Severin.

A STRUCTURAL STUDY OF SOME CATERPILLARS.*

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Although the Lepidoptera have been studied for a long time little attention has been paid as yet to the minute description of their caterpillars. In describing a caterpillar most authors have contented themselves with the colors and markings, adding an occasional note on the structure if especially striking.

My problem, therefore, has been to discover external structures characteristic of the groups of caterpillars, especially such as have been less carefully studied by others. This paper then deals mainly with the parts and setae of the head. I have also summarized my studies on the prolegs, and have included some of Dyar's characters derived from the body-setae. I have tried so far as possible, to lay emphasis also on such characters as could be determined from the cast skin. It appears that, with a little care since they are brittle, the characters of the head can be made out quite as easily from cast skins as from killed material. The body can not be studied quite so well, but at least the arrangement of the proleg hooks, and also the type of vestiture, whether primary, secondary or tufted, can be made out without trouble.

Material and Methods.

My material is made up of specimens representing about 125 genera, preserved in various ways. The major part were collected personally in the course of the past summer and preserved in alcohol. There were also a few cast skins, and a few caterpillars dried whole without any preparation. To this I added a number of species from the American Entomological Company, which were preserved in formalin, and a series of inflations, mostly of Microlepidoptera, from Staudinger and Bang-Haas.

Most of my alcoholic material was cleared by boiling in 10 per cent. caustic soda, cutting the skin down one side, and separating the maxillae and labium from the rest of the head. The dried caterpillars were treated in the same way. Often one mandible was also removed to give a clearer view of the labrum. The prepared skins were then preserved in alcohol, except a few that

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were mounted in Farrant's gum-glycerine. The same method was tried on formaldehyde specimens, but with much less success, as the muscle would not dissolve easily and had to be picked out piecemeal.

The remainder of the specimens were examined entire, as opaque objects. By placing them in full sunlight, or even concentrating it on them with a lens, they could be examined successfully, even with rather high powers of the microscope. A binocular microscope was very useful, especially in getting a correct idea of the relations of parts, in dissecting, and in hunting for setae.

Inflations of the smaller species were sometimes immersed in xylol, or in absolute alcohol, when they could be examined by transmitted light. They did not collapse on being taken out and dried again.

Most of the drawings were sketched with the camera lucida, the details being put in free-hand under a higher power. They were not drawn to a single scale, as they differ a great deal in size, and the size is of little classificatory value.

The purchased specimens were received with names. In the case of the others, which were named by the writer, there was often some uncertainty, as indicated by question marks in the text. This was especially the case in the Noctuidae and Geometridae, where I have listed less than half of my specimens.

* * * * * * * *

I wish to express my thanks to the many who have made this study possible by their help in supplying specimens, in allowing the use of instruments and books and by advice and information.

Wm. T. M. Forbes.

STRUCTURE.

A caterpillar is an insect larva in which the thorax and abdomen are similar in general appearance, the head alone is heavily chitinized; there is no sclerite between the antennae and the mandibles; the mouthparts are small and largely retractile, with lacinia not recognizeable as such and no glossæ or paraglossæ. The whole structure of the maxillæ and labium is peculiar and not closely paralleled in other orders.

Most of the head as seen from in front, is composed of the two *epicrania* (compare Fig. 1), each of which usually bears eleven primary setae and the eyes. There are also almost always

present additional setae or punctures, mostly in the neighborhood of setae i and ii. (One pair of punctures is shown in the figure).*

Lying above the mouth and separating the epicrania is a triangular sclerite, the *front.* It has two setæ near its lower outer angles, and usually between them a pair of punctures. In *Hepialus*, however, the setæ lie between the punctures. The front and the epicrania are separated by a pair of narrow *adfrontal* sclerites, each of which has two setæ and a puncture between them.†

Bordering the lower side of the front is the *clypeus*, with a pair of setae at each end; and hanging from that, the movable labrum, which belongs functionally to the mouth. Its structure will be mentioned with that of the mouthparts.

On each side, between the two articulations of the mandible is the antenna. (Fig. 29.) It is four-jointed, but all but the second of these are minute. There is a large membranous cone at the base, which Scudder treats as a true joint. It is inverted when the antenna is retracted, and would seem to be no different from the membrane which separates all the joints of the antenna. The antenna is surprisingly constant in its structure, the arrangement of setæ shown in the figure occurs with little change in all the caterpillars studied. The Lasiocampidae alone have a few secondary setæ.

The mouth parts are the labrum, or upper lip (Fig. 12), the two mandibles (Fig. 28), and the lower lip (Fig. 2), which in caterpillars is formed of the maxillae as well as the labium. The *labrum* is oblong, wider than high, with the free edge rounded, and with a notch, through which the food is guided into the mouth. It bears (1) a row of four setæ across the top of the notch (i and ii), (2) two pair of setæ on the lateral edge (iii and iv), (3) two pair of setæ on the tip of its two lobes (v and vi). There are several punctures, the most noticeable of which is the one indicated in the drawing and marked *ia.* On the inner side there are a large number of sensory cones, and near the outer edge three larger similar cones. The latter are indicated in outline on the figure. The labrum has been especially useful in furnishing characters.

† The front, as the term used in this article, has been usually called the clypeus, the adfrontals being known as paraclypeals, and the clypeus as anteclypeus or epistoma. I believe that the set of names used here agrees better with their homologies in other orders.

* Dyar's numbering of the setae, which has been copied in Fig. 1, is published in Journ. of the N. Y. Entomological Society IV, 93, with a figure.

It varies considerably in the position of its setæ, and is flat, not easily distorted, and easily studied under the microscope. The setae which appear on the margin in figure 12 have often migrated inward a distance on the surface of the labrum, and in different groups it is different setae that have migrated. As is often the case these differences define smaller groups in the butterflies, than in the moths. For example, vi has migrated up toward ii in the Sphingidæ, in Apatelodes, which shows other resemblances to the Sphingidae also; and in a part only of the Nymphalinae among the butterflies. (Figs. 14 to 18). iii migrates inward in the Pierids. Another striking arrangement occurs in the Skippers, as shown by Figs. 23 and 24.

The *mandibles* are the heavy jaws, and are the only ones used for biting. They bear two setæ on the outer side and the edge is more or less notched, the notches of the two sides fitting into each other. Taxonomically they seem more characteristic of genera than of larger groups. The position of the distal seta far out on the scrobe, as shown in the figure, is typical of the Sphingidæ. The Arctiidæ show interesting variations in structure of the mandibles.

The *labium* forms the middle of the hind margin of the mouth. It is roughly cylindrical. The basal part is formed by a long, usually lightly-chitinized joint, the *mentum*, which bears two setae near its middle. Resting on that is the heavy ring-shaped sclerite, *a*, whose setæ are shown in the figure as free in the membrane distad of the sclerite. This is often the case. The tip of the labium is retractile, and therefore largely formed of membrane (see Fig. 3). Projecting from its center is the cylindrical or flattened spinneret, which is of membrane, strengthened by three chitinous bands. Surrounding the base of the spinneret is the ring, *c*, composed of an inner and an outer semicircular sclerite. It bears a puncture at each side, and may be either very wide and heavy as in the *Psychidae*, or reduced to a narrow ring about the puncture, as in typical *Noctuidae*. The *labial palpi* spring from an area of membrane on each side of *c*. There is one large and one minute joint, each bearing a seta. In Catocala there is also a rudimentary basal joint. The remaining sclerite, *b*, of the labium forms a semicircle about the base of the palp. It bears two punctures at its ventral end.

The *submentum* is divided into a pair of triangular sclerites at the base of the labium. These are usually separated by the base of the mentum. (Compare Figs. 2 and 25).

All the parts of the labium and maxillae are described as if looking at the exposed surface from below or from behind according to the position in which the caterpillar holds its head. This surface morphologically consists of the caudal aspect of the labium, and the caudo-lateral aspect of the maxillae.

The *maxillae* are fused at the base with the labium, but are free at the tip. The main part is made up of a usually lightly chitinized joint, the *stipes* (plus the palpifer) which bears two setae at its distal end. The *cardo* forms a small triangle between the base of the stipes and the submentum. At the tip of the stipes there are two very incomplete rings, which would seem to be the basal joints of the palpus, but which are completely fused with the maxilla proper. In Hepialus the more distal of these is shaped like a normal joint of the palpus, and in Micropteryx, according to Packard, it is free. From the end of these arises the two-jointed free part of the palpus, and mesad of this springs the large basal joint of the galea, which forms an incomplete ring. The tip of this joint bears the two maxillary lobes (which are the distal joints of the galea and lacinia?), and is also armed with two large cones (anterior to the maxillary lobes in Frenatæ, and mesad to them in Hepialus), two small cones (posterior to the maxillary lobes) and a step-cone between them. The latter is composed of a larger chitinous ring, bearing a thin-walled cone at its tip. Each of the maxillary lobes, also, bears a sense-cone at its tip.

Chitinous sclerites are but little developed as a rule on the body. The greatest development that I have seen on the abdomen occurs in Incurvaria. In this caterpillar each segment has two dorsal and two ventral plates (see Fig. 34). The anterior ventral plate, or *sternum*, extends between the prolegs.

The thorax has more extensive sclerites in *Adela*, as the sketch of the pro- and meso-thorax (Fig. 35) shows. Not many of the sutures are traceable, so that they can be only roughly homologized with those of other insects. The præsternum and sternellum of the prothorax are more distinct.

In higher caterpillars only the coxæ, which are divided by a clear suture into coxa and meron, are preserved. Besides the coxæ, the legs have very short femurs and tibiæ and a single-jointed tarsus, which bears one claw.

One of the chief characteristics of the caterpillars is the definite arrangement of setae. These are either primary, which

are common to all the caterpillars, and many of which can be homologized with setae occurring in the *Trichoptera* and *Panorpata;* or they are secondary, in larger numbers, and not definitely arranged. The setæ are more or less completely carried over into the pupa, with comparatively slight changes in their arrangement. Often in place of the primary hairs there are tufts of hair springing from the same wart. This is the condition spoken of as "with tufted hair." In such caterpillars as *Melalopha*, this is due to the occurrence of secondary hair on the tubercle of the primary hair, which remains quite distinct, but in the *Arctiidae* it seems rather to be a reduplication of the primary hair.

Where the secondary hairs are very few, like the primaries, they take definite positions, and are then known as subprimaries.

The arrangement of the primary setæ on the meso- and metathorax of the typical Frenatæ is shown in figure 4, while different arrangements for the abdomen are shown in Figures 5, 33 and 34. The small primaries numbered *iiia*, *ix* and *x* are usually overlooked. The numbering of the others is after Dyar, except that figure 33 is changed to make it agree with the others.

The prothorax has its arrangement modified by the persistence of three sclerites, the *cervical shield*, with many setæ and some punctures, the *prespiracular wart*, with two or three setæ (sometimes fused with the cervical shield) and the *subventral wart*, with two or three setae.

Tufted or secondary hair on the body is usually accompanied by secondary hair on the true legs and head. It reaches its greatest development in the Lasiocampidae, where it occurs even on the antennae and palpi, and on the sclerites, *a*, *b*, and *c* of the labium.

PROLEGS.

One may take as a typical proleg that of the *Tortricidae* or higher *Tineidae*. It is a fleshy, more or less conical projection, the tip of which, the *planta*, is more or less retractile, and rounded or flat. Around the edge of the planta is a series of hooks or crotchets, each imbedded about two-thirds its length in the skin, but with the tip free and hooked toward the center of the circle. To the center of the planta is attached a muscle, by which it can be completely inverted, even the hooks disappearing from sight. Just above the hooks on the outer side there may be a horny edge, and above that, a larger plate bearing three setae (vii). On the front of the base is a minute seta (sometimes entirely in front of the leg,) and on the inner side another (viii).

The possibly primitive state of the proleg can perhaps be reconstructed from Adela and Incurvaria. Each segment bore on the ventral side two chitinous sclerites, between which was a fold of membrane, which was rough with minute conical granulations like the rest of the skin. In this membrane there may have developed a concave fold, which lost its granulations, while those at each edge of it were enlarged, and became regularly imbricated, gradually becoming like the unmodified granules as you go away from the fold toward the two sclerites. This is the condition of Adela, (Fig. 6), except that the sclerites still preserved in Incurvaria, are lost. On segment A6 the front side of the fold only develops hooks, and the folds of the remaining abdominal segments (1, 2, 7, 8, and 9) are traceable, but entirely without hooks. There are no anal legs.

In Incurvaria (Fig. 7) the posterior rows of hooks have disappeared on all the segments, so that A6 is no longer different from A3 to 5, and the hooks are reduced to a single row.

Hepialus has kept two rows of hooks, and in part, three, but the terminal row is much more highly developed, while the others are quite rudimentary. The two bands have fused on the inner side, and approach each other on the outer side, thus enclosing the fold, which becomes the planta. In many higher micros the outer ends have also fused, making the circle (ellipse) complete. In all above the Tineidae there have developed hooks on the last segment, but there is never a posterior series, or a complete circle; in some there is a straight band, which becomes a loop, but is always open posteriorly. It is nearest a circle in the Psychidae and lower butterflies. In the higher forms (butterflies and Noctuidae for instance), it has again become straight, but longitudinal, by the disappearance of the outer hooks.

The ventral legs have a similar evolution. The circle which serves as a type for all the higher species may be broken on the outer side (*Pyralididae*), on the inner side (*Psychidae*), or on both (*Ægeriidæ*). It may be broken in front and back (*Papilionidae, Thyatiridae, Libytheidae,*) and in that case the outer half becomes weaker, and then disappears, leaving an inner band only (*Noctuina, Bombycina*, higher butterflies, etc.)

In the *Tineina* the last ventral legs may entirely disappear (as has been mentioned they are only half developed in the very primitive type Adela) while in several higher families the first ventrals are lost (*Noctuidae, Geometridae, Nolidae*). In the

Thyatiridae, Drepanidae and *Notodontidae* the last legs either disappear or are modified, while in the lowest Tineids they may have never developed (Adela, Incurvaria). In the *Eucleidae* and *Nepticula*, as well as some other leaf-miners there are no hooks at all on the prolegs, but the area of roughened skin in Nepticula suggests an even more primitive condition than occurs in Adela.

The *Lycaenidae*, as well shown in Scudder's figure, have developed an outer fleshy lobe, apparently from the planta. The planta is apt to be unrecognizable in those which have lost the outer part of the circle of hooks, but its retractor muscle serves as in the lower ones to withdraw the hooks that remain. (Compare Jasoniades with Papilio).

In Lagoa the line of hooks is sharply angulate at the middle and there the hooks are shortened.

Another variation is in the arrangement of the hooks in the band. In the most primitive forms all those in a single line are of equal length gradually decreasing to the end, but a little higher in the scale, there develops an alternation of length by which the hooked tips are thrown into two or more ranks. In many of the highest families the single length again prevails, apparently as a secondary modification. In the lower forms (Micros) these two arrangements intergrade, but in the Macros they separate families or even superfamilies very sharply.

The proleg typically bears four setae, three on the outer side (vii) and one on the inner or anterior side (viii). The minute primary ix may migrate up on to the anterior side.

HOMOLOGIES AND NAMES OF THE PARTS OF THE HEAD.

About the identity of the front and clypeus; and of course of the mandibles, labrum, maxillae and labium as a whole, there can be little or no doubt. The epicrania, as the name is used in this paper, include also a number of other sclerites which are fused with it so completely as to show no suture. A large part of the epicrania becomes the compound eyes in the imago. The postgenæ will not be discussed to any extent, but they are quite distinct.

The naming of the parts of the maxillæ and labium on the other hand has been done mainly in order to refer to them intelligibly. Such grounds as I have for this tentative homologizing may be largely drawn from the figure of the Elaterid beetle larva,

figure 25. The arrangement is about the same in Phryganea (one of the herbivorous caddis-flies), but in a sawfly, as shown in figure 32, there is no close relation to the others, the modifications having taken quite a different direction. In all three of these non-lepidopterous types the lacinia of the maxilla is well developed, but in the Elater the proximal joint of the galea is open on the inner side, and one can see how the lacinia might easily fuse to it in much the same way as the galea is fused to the two basal joints of the palpus in the higher caterpillars.

Especially striking is the complete disappearance of the glossæ and paraglossæ, not only in the larvæ figured, but in the adult Elater also. The setae marked *ai* and the more ventral of the two sclerites which form the ring *c*, come closest to the normal position of the glossæ and paraglossæ.

Artificial Key to the Families of Frenatæ.

(Incomplete in the Microlepidoptera.)

1. Prolegs each of one or two transverse bands of rudimentary hooks, no anal prolegs.......... **Tineidae**
1. Hooks of prolegs in curved or longitudinal bands, or in a circle, anal prolegs wanting only in Drepanidae.......... 3
1. No prolegs, or prolegs without hooks.......... 2

2. Slug-caterpillars, exposed feeders.......... **Eucleidae**
2. Slender leaf-miners.......... **Nepticula** and other **Tineina.**

3. Hooks of prolegs in two curved transverse bands .... **Ægeriidae**
3. Hooks of prolegs in a complete circle or horseshoe.......... 4
3. Hooks of prolegs in a longitudinal band, on inner side of leg, with or without a rudimentary outer series.......... 8

4. With much fine secondary hair.......... 5
4. With a single subprimary on the proleg.......... **Lacosomidae**
4. Without secondary hair.......... 6

5. Head much larger than second segment.......... **Hesperiidae**
5. Head smaller than second segment.......... **Megathymidae**

6. Circle of hooks interrupted caudo-mesally, and as complete on anals as on the other prolegs.......... **Psychidae** 7
6. Circle of hooks complete, or interrupted outwardly, anal prolegs with a shorter, straight or curved band.
The typical Micros, including **Cossidae, Thyrididae** and **Orneodidae.**

7. Seta i of abdomen dorsal of ii, front much higher than wide.......... **Solenobiinae**
7. Seta ii of abdomen dorsal of i, front as wide as high.......... **Psychinae**

8. Hooks of prolegs alternately of three lengths, at least with some short hooks on anal prolegs.......... **Papilionina** 9
8. Hooks of prolegs alternately of two lengths.......... 21
8. Hooks of prolegs of the same length, or gradually growing shorter to the end of the rows.......... 12

9. Maxillary lobes minute; labrum with 18 or more secondaries.......... **Papilionidae**
9. Maxillary lobes at least half as long as terminal joint of palpus; labrum with less than 18 secondaries.......... 10

10. Slugcaterpillars with small heads.......... **Lycænidae**
10. Normal cylindrical caterpillars.......... 11

11. Seta iii of labrum as near to ii as to iv, far from margin........**Pieridae**
11. Seta iii of labrum on margin ....**Nymphalidae**

12. Hooks of prolegs in an angulated band, shortest at the angle; with additional prolegs (two pair) without hooks.............**Megalopygidae.**
12. Hooks of prolegs in a straight or curved band; no additional prolegs...13

13. Anal prolegs reduced or modified, with fewer or no hooks..**Notodontidae**
13. Anal prolegs larger than ventral ones...........................14

14. With dense fine secondary hair on head, body with tufted hair........15
14. With some sparse secondary hair on head, body with tufted hair..**Arctiidae**
14. Without secondary hair on head, body often without secondary or tufted hair...17

15. Eversible dorsal glands on posterior abdominal segments; a tuft of secondary hair on the adfrontals; five warts on mesothorax.......**Liparidae**
15. No eversible dorsal glands; no such tuft of secondary hair...........16

16. Three warts on mesothorax, the upper very large..........**Syntomidae**
16. Four nearly equal warts on mesothorax...........**Noctuidae (Pantheinae)**

17. Body with primary hair only............................**Noctuidae**
17. Body with tufted or secondary hair.............................18

18. Fourteen legs (first prolegs wanting)........................**Nolidae**
18. Sixteen legs 19

19. Two warts above spiracle on each segment of abdomen..........
Zygaenidae (Pyromorphidæ)
19. Three warts above spiracle on each segment of abdomen, or with secondary hair..20

20. Adfrontal puncture three times as far from lower as from upper seta..
Arctiidae
20. Adfrontal puncture not more than twice as far from lower as from upper seta .... **Noctuidae (Acronyctinae)**

21. Without secondary hair.......................................22
21. With dense fine secondary hair (often minute)....................23

22. Anal legs wanting; a series of small outer hooks on prolegs..**Drepanidae**
22. Anal legs reduced; a few outer hooks on prolegs..........**Thyatiridæ**
22. Anal legs large; ventral prolegs reduced or wanting; no outer hooks on prolegs.. **Geometridae**

23. Secondary hair on antennae, palpi, and sclerites a, b and c of labium
Lasiocampidae
23. No secondary hair on antennae, palpi, or tip of labium...............24

24. Seta vi of labrum distant from margin, migrated toward ii*...........25
24. Seta vi of labrum marginal or nearly so..........................26

25. Hair microscopic; without tufted hair..................**Sphingidae**
25. Hair conspicuous; with tufted as well as secondary hair....**Apatelodes**†

26. An unpaired dorsal spine or tubercle on ninth abdominal segment
Citheroniidae
26. Usually with an unpaired dorsal spine on eighth abdominal segment, but never with one on the ninth....................**Saturniidae**

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* This separation does not entirely hold, see the descriptions of the individual families.
† Probably does not belong to the Notodontidae.

SPECIAL PART.

THE SUBORDERS.

JUGATAE: Unfortunately I have only the highest family, Hepialidae, of this suborder for examination. Probably the head characters will hold in the other families, so far as they are primitive in their nature, such as the palpi, ocelli and galea, but the others will be very likely to fail.

Frontal punctures more widely separated than frontal setae; the four anterior eyes arranged in two pairs; galea with the area of membrane on the mesal aspect, one of the large cones being shifted far proximad on that side; second joint of palpi more distinct than in the Frenatae and shaped like the free distal ones; an anterior subdorsal seta present on the meso- and metathorax, besides the minute primaries; iiia of abdomen large and dorsal to iii; ix of abdomen large, on leg-base.

The abdominal setae iv, v and vi of Hepialus hectus are arranged very much as in Incurvaria. The hooks of the prolegs form a circle broken shortly on the inner side; they are all of one length, but there is a double series of rudimentary hooks at their base.

Figures 27, 30, 33.

FRENATAE (including Rhopalocera): Frontal punctures closer together than frontal setæ; the four anterior eyes forming an arc of a circle; base of galea with the area of membrane on the anterior side, and with the large cones nearly opposite the maxillary lobes; first two joints of palpi quite similar, very short, and completely fused into the maxillae; no anterior subdorsal seta on thorax (except in Lithosiidae, which are otherwise very highly developed Frenatae); iiia of abdomen minute, usually lying between iii and the spiracle; ix of abdomen minute.

The prolegs of Adela are probably more primitive than those of Hepialus.

SUPERFAMILY PAPILIONINA (including the Hesperiina): *

Prolegs with hooks alternately of three, very rarely of two, lengths, either in a complete circle or a straight line. Secondary hair present (on body, epicrania, front, mandibles and stipes, and sometimes everywhere except on the tips of the mouthparts and the antennae.) Labium narrower than the maxillae, and narrower at the base than one of the submenta.

* See Scudder, Butterflies of Eastern North America; for a good many additional characters, and for descriptions of all the known eastern species.

Of the Hesperiina I have seen no caterpillars of the Megathymidæ. The characters I have italicized should be expected to apply to them as well as the Hesperiidæ, while the small, normal head will separate them.

1. Labrum very shallowly notched, all six setae near the outer edge; cervical region chitinized in two pair of sclerites, which fuse more or less to the corresponding sclerites of the head; postgenae very wide. Large cones with a tuft of branches (unique). *Prolegs with hooks in a complete circle*, or *shortly broken on the outer side;* part of primaries modified into flat plates, the others inconspicuous. *Labial setae ai close together.* *Hesperiina, Hesperiinae*

* Feet with 125 hooks, alternately of 3 lengths. Head square; postgenae with setae; adfrontals abruptly widened at top of front; gula as wide at base as it is long. Example: *Epargyreus tityrus* (Fig. 23).

* Feet with 50 hooks, alternately of two lengths; head heart-shaped; postgenae fused with gula and without setae; adfrontals very wide and long; gula twice as wide. Example: *Pholisora catullus.* (Fig. 24).

1. Labrum usually with setae normal (about as in Noctuidae) not all on the terminal margin, usually moderately notched; cervical region not chitinized, postgenae meeting, or else very narrow. Large cones simple, normal. Proleg with hooks never in a complete circle or horseshoe (the outer band preserved only in Jasoniades, Euphoeades) primaries unmodified, usually similar to secondaries; labial setae *ai* widely separated. *Papilionina* go to 2.

2. Labrum with about 18 secondaries. Maxillary lobes very small, front wider than high, not reaching half way to vertex; clypeus as broad as 1-3 height of front, with many scattered secondaries, primaries separated by half the distance that separates the two primaries i from each other. Lower end of adf. about as broad as clypeus. *Papilionidae*

* Feet with an outer row of 45 small hooks and an inner row of 80 large ones. Example: *Jasoniades glaucus* (Figs. 11 and 22.)
Euphoeades troilus.

* Feet with a single row only of about 50 hooks.
Example: *Papilio polyxenes* (Figs. 10 and 21.)
Laërtias philenor.

2. Labrum with less, or usually without secondaries. Maxillary lobes at least half as long as last joint of palpus. Front higher than wide (except in Anosia) usually reaching more than half way to vertex; clypeus usually much narrower, and with less or no secondaries, when widest the adfrontals are only about half as wide as it at the bottom. go to 3.

3. Head small and body stout; prolegs with fleshy outer lobes curving down over the row of hooks; clypeal setae very far apart; about as in Papilio, but on a narrow clypeus. Seta iv of labrum some distance from the margin. Adfrontals apparently very narrow. *Lycaenidae*
Example: *Thecla ilicis.* (Fig. 38.)

3. Head at least half diameter of body, which is approximately cylindrical; prolegs normal; seta iv of labrum variable. Claws of true legs deeply lobed. go to 4.

4. Primaries on body mostly distinct, in *P. brassicae* conspicuous; adfrontals very narrow; clypeal setae far apart; iii of labrum distant from margin nearly as far as from seta ii. *Pieridae*
Example: *P. rapae*, (Fig. 20), *P. brassicae.*

4. Primaries on body not distinguishable from secondaries, at most a little larger; adfrontals about 1-5 as wide as height of front; clypeal setae separated by a distance not more than ⅓ that between the two setae i; iii of labrum close to margin. *Nymphalidae*

5. Prolegs with outer hooks (4 scattered ones); segments of abdomen divided into four equal annulets, each bearing a row of larger black setae. *Libytheinae*
Example: *L. celtis.* (Fig. 37.)

5. Prolegs with the inner row of hooks only; one annulet of each segment broad; the larger black setae, if present, irregularly arranged, or on spines. go to 6.

6. Front broad and epicrania high (as in Papilio) labrum with secondary setae; mentum only 1-4 as wide as stipes. *Euploeinae*
Example: *Anosia plexippus* (Fig. 12).

6. Front much higher than broad, and usually reaching more than half way to vertex; labrum with very few or no secondary setae; mentum wider. go to 7.

7. Labrum with i and ii low down near margin, and notch very shallow; mentum without secondaries; two minute points projecting back from rear of body, but otherwise unarmed. *Satyrinae*
Example: *Cercyonis alope.* (Fig. 19).

7. Labrum normal, with moderate notch, setae all about equal and i and ii far above the level of v and vi; mentum with secondaries (only one odd one in my specimen of Euphydryas phaeton). Body more generally spined, (or else entirely unarmed, in Anaea). *Nymphalinae*
Examples: *Argynnis cybele.* *Argynnini* (Fig. 14).
Euphydryas phaeton. *Melitaeini* (Fig. 15).
Polygonia interrogationis. *Vanesiini* (Fig. 16).
Euvanessa antiopa. *Vanessini* (Fig. 17).
Basilarchia disippus. *Nymphalini* (Figs. 18 & 36).

Spines very unequal in Basilarchia.

No unpaired spines in Basilarchia, Argynnis.

Two unpaired spines on last segment in Euphydryas.

Two spines to a segment in subventral row in Euphydryas.

Hooks of prolegs less regularly arranged in Basilarchia.

Ventral legs with hooks of two lengths only in Euphydryas, of four lengths in Polygonia.

30 hooks in Euphydryas, 50 in Vasessini, 60 in Basilarchia.

Clypeus and adf. without secondary setae in Basilarchia.

Mentum with most setae in Euvanessa.

Postgena wider in Euvanessa.

Labrum with secondary setae in Argynnis.

THE SPECIALIZED MACROFRENATÆ.

Following the Butterflies there comes a series of families which include the larger and better-known moths. These may be divided for convenience into two groups, which perhaps represent very early-separated lines of descent.

The first group, which seems to be especially associated with a tree habitat, may be roughly defined by the presence of four setae on the outer side of the legplate (the upper one of which will be spoken of in this article as *vib*), by the usually rather small front and large epicrania, and especially by the hooks of the prolegs, which are alternately of two lengths. The caterpillar very frequently has secondary hair, obscuring the arrangement of the primaries; and the imago shows a very strong tendency to lose the frenulum. (It is minute or wanting in the Saturniidae, Ceratocampidae, Lasiocampidae, Endromidae, Bombycidae, Drepanidae and Lacosomidae, also in a few Sphingidae and Geometridae). Most of the families are small, and the type, except as

represented by the Geometridae, seems to be geologically past its prime.

On the other hand the group typified by the Noctuidae is the dominant modern type of moths. Though they are much more uniform in adult structure, there is a vast number of species, and a surprising variety of larval types. In these families the outer side of the leg-base never has more than the three typical setae of *vii* unless tufted hair is present. There is never but one length of hooks on the prolegs; the front is usually somewhat larger in proportion. Secondary hair is very rare, occurring only in Thaumetopœa, Panthea and Apatela, and only in some species of the latter. A decided majority of the species live on low plants.

GROUP I. (*with vib, and usually with secondary hair*).

This group again can be divided for convenience into two sections, those with and those without secondary hair. The first includes the Sphingidae, Saturniidae, Bombycidae, Lasiocampidae and related families: the second, the Notodontidae, Thyatiridae, Drepanidae, Geometridae, and Lacosomidae, doubtless also the Epiplemidae and Dioptidae.

The Notodontidae have been an especially puzzling group. Apatelodes shows no distinct affinity to the others, but is in every traceable way more like the Bombycidae and Saturniidae. In hairiness it surpasses both, and approaches the Lasiocampidae. The single-haired Notodontidae (such as Cerura and Heterocampa) show seta *vib* unmistakably. Datana has secondary hair on the body, and in Melalopha it has invaded the head and the tubercles, producing a kind of tufted hair in which the primaries still remain dominant. The distribution of hair on the head is quite different from that of Apatelodes, with which the moth has been associated. In most ways it would seem more natural to derive the series from the Thyatiridae, and consider such genera as Gluphisia and Nadata, primitive. Still the hairy prolegs of Gluphisia* and Nadata would point toward an origin from the series with secondary hair. In the latter case the primitive Notodontan must have had very nearly the structure of Melalopha, with a recessive tendency to have a seta *vib*.

Lacosoma is a synthetic form between the rest of the series and the Microlepidoptera, with positive relations to both, as will be discussed under the heading of its family.

* See Packard's figure, Monog. Bombyc. I. Pl. Fig.

SPHINGIDAE.

Minute secondary hair on epicrania, front, adfrontals, maxillae, labium and body; none on clypeus, labrum, mandibles, or distal parts of maxillæ and labium; primary hairs *iii* and *iv* of abdomen usually distinct (directly above and below the spiracle), *i*, *ii* and *iii* of epicrania also sometimes distinct, never with tufted hair or branching spines. Epicrania large, extending more than the height of the front above its top, usually much more. *ii* of adfrontals about at their middle (they are usually the lowest setae the adfrontals bear); labrum with *vi* decidedly more distant from the margin than *v*, *iii* and *iv* not very close together; mandible with one seta far out near tip of scrobe; mentum very wide at base, without distinct submenta; prolegs with a single band of hooks alternately of two lengths, the anal prolegs the largest; caudal horn present except in Ellema.

SESIINAE: Primaries i, ii and iii of epicrania easily recognized by their enlarged punctures; lower ocellus rather farther than usual from the others; front wider than high, its width nearly half as great as height of head; adfrontals very narrow and with very irregular outer margin; clypeus very narrow, the setae close together, separated by only about 1-7 the distance between the two setae *i;* head setae black and conspicuous under a lens; labrum with setae *i* and *ii* in a straight line, *iii* farther from the margin than *iv*, *vi* distant from the margin only about 1-6 of height of labrum, notch shallow; two conical spines on anal plate.*

Example **Pseudosphinx tetrio,** Figs. 47 and 50.

(The remaining subfamilies have primaries of epicrania rarely distinct, front usually higher than wide, adfrontals wider, clypeus usually wider, especially at the two ends, with the setae of each pair farther apart, head setæ colorless, labrum with setæ *i* and *ii* out of line, *iii* often as near the margin as *iv*, *vi* usually much higher, and the notch much deeper, anal plate unarmed).

ACHERONTIINAE (Sphingicae only were examined). Head higher than wide, rather regularly rounded, or moderately tapering toward the vertex, a large number of very minute setæ on the epicrania, averaging eight or ten in a portion of the epicrania the size of the front, arising from depressions on the surface, front with very sinuous margins, labrum deeply notched; skin usually smooth in last stage; horn always normal.

Body rough and granular, four short soft horns on thorax; two oblique lines of granules on each segment besides the mid-dorsal line; labrum with v distant from margin; mandible with teeth less distinct than usual in the family; posterior ocellus rather high, front only 1-3 height of head and with exceptionally sinuous outer margin; head distinctly tapering toward vertex, widest near base.

Example **Ceratomia amyntor** Figs. 45 and 49.

Widest point of head about halfway up; front proportionately very wide toward the apex. Horn at the middle about as thick as at base. Posterior ocellus a little lower; front about two-fifths height of head.

Example **Sphinx gordius.**

* Hemaris is less aberrant.

Head decidedly tapering upward, upper part of front narrow, horn tapering regularly; otherwise about as in Sphinx.

Example **Dolba hylaeus** Figs. 39–41.

Labrum much less deeply notched, head intermediate between that of gordius and hylaeus; front hardly more sinuous than in Deilephila. Horn strongly curved and regularly tapering.

Examples **Phlegethontius celeus.**
P. sexta. Fig. 51.

AMBULICINAE: Head much higher than wide and tapering much to the vertex; epicrania with only three or four setae in an area the size of the front, set on decided tubercles; front with margins sinuous as in the preceding subfamily, quite small proportionately; Labrum very deeply notched. Skin rough, horn always conical, variable in size.

Example **Paonias myops** Figs. 42–44.

PHILAMPELINAE: Head squarish; front small in proportion to head, and higher than wide; with much straighter margins than in the preceding groups; posterior ocellus low, as near to lower ocellus as to the fourth one; labrum deeply notched; a subspiracular ridge on the anterior segments, disturbing the incisure between thorax and abdomen; skin always smooth, horn variable.

Head wider than high, third ocellus much enlarged; caudal horn shorter than height of head; supraanal plate nearly an equilateral triangle, and acute at tip.

Example **Amphion nessus.** Figs. 48 and 53.

Head higher than wide, with the sides nearly parallel; third ocellus much enlarged, caudal horn nearly normal; supraanal plate as narrow as in the last, but with the tip rounded off.

Example **Darapsa myron.**

Head higher than wide, the sides converging somewhat toward the vertex, caudal horn replaced by a low button; supraanal plate broad and rounded.

Example **Pholus pandorus.**

CHŒROCAMPINÆ: Head decidedly wider than high, the upper part nearly spherical; epicranial seta *ii* distinct; posterior ocellus high, half farther from lower than from fourth ocellus; front wider than high, its width equal to about half height of head, its margins nearly straight, as in the last subfamily; clypeus quite narrow with the setae close together as in the Sesiinae; labrum with notch shallow; *i* and *ii* nearly in a straight line; *iii* farther from the margin than *iv*; *vi* not very far from the margin. This comes nearer than any of the others to Pseudosphinx.

Example **Deilephila gallii** Figs. 46 and 52.

APATELODES.

Secondary hair on epicrania, front, adfrontals, mandibles, maxillae, labium and body, but not on distal parts of maxillae and labium or on clypeus or labrum; tufted hair also on body. Front rather large, the epicrania extending about its height above it, labrum with setae *vi* quite distant from margin, *iii* and *v* also not marginal. Secondary setae of labium arranged in two diverging rows. Setae *ai* of labium close together. Prolegs with hooks in a single band, alternately of

two lengths. No caudal horn. Frontal punctures close together, but the setae *i* are also close together. Mentum somewhat wider at the base than one of the submenta.

It may be distinguished from the Saturniidae by the much denser hair on the maxillae, the larger front and the fact that setae *a i* of the labium are much closer together. This genus is entirely isolated in the North American fauna, it is perhaps most often placed with the exotic family *Eupterotidae*.

Examples **A. torrefacta** Figs. 54, 55 and 56.
A. angelica.

Lasiocampidae.

Very dense secondary hair on all parts except the tips of the palpi, even on the antennae; tufts also present (*i*, *iii*, *iv* and *vii*), but reduced: front rather small, the punctures close together, and the primary setae rather close together; adfrontals enlarged opposite top of front, with the setae close together. Prolegs with hooks alternately of two lengths in a single row.

Second joint of antenna three times as long as wide. Labrum with most of the secondary hair toward the tip of the lobes; prolegs spread laterally; a low tubercle in place of caudal horn; lappets on legless segments simulating the legs, also on first segment each side of the head.

Example **Artace punctistriga** ?.

Second joint of antenna twice as long as wide, labrum with most of the secondary hair in the neighborhood of setae i and ii; no lappets or tubercles, prolegs normally placed.

Examples **Malacosoma americana.**
M. disstria (Figs. 59 and 60).

Saturniina.

Secondary hair on epicrania, front and body, and sometimes on adfrontals, mandibles, maxillae, and labium; tubercles, at least in part with tufted hair; tubercles *ii* of either eighth or ninth abdominal segments fused across the middle line (that of the eighth would be the caudal horn), except in Saturnia; mentum wide, its base wider than one of the submenta; prolegs with hooks alternately of two lengths, in a single band; setae *ai* of labium far apart; punctures of front far apart, with reference to the setæ, but close together in comparison to the width of the front.

Ceratocampidae: Tubercles ii of ninth abdominal segment fused.

Adfrontals, maxillæ and labium without secondary hair; front as wide as high and head wide; *ii* of adfrontals about 2-5 up the front; clypeal setæ close together; secondary hair of body minute; armed with many long horns.

Example **Citheronia.** Fig. 63.

Maxillæ with secondary hair but none on adfrontals; front wider than high, *ii* of adfrontals only 1-3 way up it; clypeal setae close together; head as wide as high; secondary hair of body long.

Example **Basilona.** Figs. 61 and 65.

Maxillæ, adfrontals and labium with secondary hair; head and front both higher than wide; adfrontals wider; both *v* and *vi* of labrum distant from margin; secondary hair of body minute.

Example **Anisota.** Figs. 62 and 64.

SATURNIIDAE: Tubercles of ninth abdominal segment separate.

Labrum notched about half its depth; adfrontals without secondary hair, the puncture very close to the upper seta; secondary hair of labium in two parallel rows, (as in Apatelodes) secondary hair also on maxilla, but not on labrum or mandible; maxillary lobes well developed, decidedly longer than broad.

Hyperchiria io. Figs. 66 to 68.

Labium with not more than one or two secondaries; mandible with secondary hair; maxillary lobes minute; labrum cleft two thirds its width or more; adfrontals with several secondary hairs.

Labrum with secondary hairs; warts of body larger, several haired.

Example **Telea polyphemus.** Fig. 69 and 70.

Labrum and warts with primary hair, warts smaller.

Example **Tropaea luna.** Figs. 71 and 72.

(The labrum in this figure is aberrant).

GYNANISA ISIS agrees structurally with this family.

ENDROMIDAE.

With secondary hair on epicrania, front, maxillae and body, but none on adfrontals, clypeus, labrum, mandible, labium, etc.; hair minute. Epicrania large and front small, higher than wide, punctures of front far apart and lower than setae; labrum deeply notched, seta *vi* a short distance from the margin, *iii*, *iv* and *v* close to the margin; mentum not very wide, about as wide at the base as one of the submenta; upper ocellus minute; prolegs with hooks in a single row, alternately of two lengths, anal legs larger than the ventrals. There are no North American species of this family.

Example **Endromis versicolor.** Fig. 57.

BOMBYCIDAE.

With secondary hair on epicrania, front, and body, and with one each (in the specimen before me) on adfrontals and maxillae, hair minute, but denser and longer than in Endromis. Tufted hair represented in adult by a single rudimentary tuft in the subventral region. Punctures, etc., about as in the Sphingidae and Saturnoidea; setae *ai* of labium moderately far apart, but not so far as in Saturniina. Basal joint (the one fused to the maxilla) of maxillary palp unusually broad. Prolegs with a single row of hooks, alternately of two lengths. Caudal horn present. There are no North American Species of this family.

Example **Bombyx mori.** Fig. 58.

NOTODONTIDAE.

Head with secondary hair, only in Melalopha; body with or without general secondary hair, but always with it on the prolegs; seta *vib* distinct unless covered by secondary hair; epicrania with setae *ii* well above the top of the front; submenta large and nearly meeting; frontal punctures farther apart than in most Noctuidae, often close to the setæ, front small, the head extending twice its height above its top; prolegs with hooks in a single band, not alternately of two lengths; anal prolegs reduced or modified, with fewer hooks; primary setæ distinct, arranged as in the Noctuidae, often on enlarged tubercles. For superficial structural characters in this family see Packard's Monograph of the Bombycine Moths, Part I.

Melalophinae: With dense secondary hair on epicrania, front, adfrontals and body, also on the tubercles, but not obscuring the primary hair; notch of labrum shallow, the setae *i* and *ii* not far out of a straight line; anal legs moderately reduced.

Example **Melalopha apicalis.** Figs. 76 and 83.

Pygærinae: Head without secondary hair; dense secondary hair on body, usually not obscuring the primary hair; epicranial setae *ii* three times as far apart as *i;* anal legs are rudimentary stemapods, with one or two retracted hooks, labrum small proportionately.

Examples **Datana ministra.** Fig. 78.
D. integerrima. Fig. 73.

Notodontinae: Without secondary hair except on prolegs; anal legs well developed in one form or another (in the species studied fairly normal), with hair about as on the other legs; epicranial setae *ii* very high up; and little if any farther apart than *i;* anal dungforks not developed.

Labrum half as high as wide, cleft about half its height. Frontal punctures close to setæ.

Examples **Schizura concinna.** Fig. 74.
S. badia.
S. unicornis.

Labrum very high and deeply cleft; frontal punctures about trisecting the space between the setae; anal legs rather more reduced.

Example **Nadata gibbosa.**

Labrum and frontal punctures similar; anal legs very little reduced.

Example **Lophodonta.**

Frontal punctures close to setae: anal legs a little longer and more conical.

Example **Heterocampa guttivitta.** Figs. 80 to 82.

Cerurinae: Anal legs modified into stemapoda without hooks and with a retractile lash, with many setae; no secondary hair except on the stemapoda and prolegs; epicranial setae *ii* intermediate in position; anal dung-forks strongly developed. Labrum moderately notched.

Example **Cerura.** Figs. 75 and 77.

Family Thyatiridae.

Prolegs with a band of inner hooks, alternately of two lengths, and with a few minute outer hooks; anal legs slightly reduced; *vib* present but without other subprimaries; epicrania decidedly wider than high, front small; adfrontals wide, with *ii* low down, frontal punctures close; labrum with *vi* slightly up from margin, and very deeply notched. Mentum rather short, but submenta nearly meet in the middle line.

Head about a fourth wider than high; a slight hump on segment A8; body with a regular pattern of marks.

Example **Habrosyne derasa.**

Head about half wider than high; body entirely lacking any hump, and entirely without marks, setae less distinct than in Habrosyne.

Example **Bombycia or.** Fig. 88.

Family Drepanidae.

Prolegs with a band of inner hooks, alternately of two lengths, and with a short band of rudimentary outer hooks; no anal legs; a subpri-

mary hair near *iii*, and from two to four in a longitudinal line between *iv* and *v*, and *vii* (*vib*): head sometimes with subprimaries, but without secondary hair; epicrania high, and head higher than wide; supraanal plate with a median horn bearing two setae at its tip; adfrontals high with *ii* near top of front; mentum short and broad, but apparently with the submenta nearly meeting; labrum with *vi* a little distance from the margin.

Three or four subprimaries on head, four setae represent *rib*; granulations long and setiform, giving an appearance of fine secondary hair; subdorsal tubercles large, and present on meso- and metathorax (*ib*), and on segment 2 of abdomen (*ii*); labral notch somewhat shallower.
Examples **Drepana falcataria.**
D. arcuata. Figs. 89 to 92.

Less subprimaries on head, two setae represent *rib* on abdomen; granulations minute and conical; subdorsal enlarged tubercles smaller on thorax, and wanting on abdomen. Labral notch very deep.
Example **Cilix glaucata.**

Geometridae.

No secondary hair, except occasionally on prolegs; at least one subprimary subventrally, often several; prolegs with hooks usually alternately of two lengths, the series often interrupted in the middle; (see Fig. 87). Epicrania full and rounded, or with the region of seta *i* produced into an angle; front large, the punctures rather closer together than the distance between a puncture and the corresponding seta; adfrontals narrow over the top of the front; clypeus and labrum normal; mandibles usually rather thin, with sharp teeth and setae close together; maxillae and labium normal, of about equal width, the mentum at the base decidedly narrower than one of the submenta.

The number of secondary setae on the proleg varies; in Cosymbia only the subprimary *vib* is present; in Alsophila and an unidentified species there is a large number; in Brephos, Hydria, Aplodes, Zerene, etc., the number is intermediate, usually one besides *vib*. Alsophila and Brephos, which have additional rudimentary prolegs, have no additional setae on them.

The planta of the Geometridae seems to be developed as a sucker on both ventral and anal prolegs and in several species the hooks in the center of the line are rudimentary to give it room. Such are Alsophila, Zerene, etc.

The ventral proleg varies in position with reference to its segments. In Brephos it is directly below its segment, in Alsophila below the incisure between its segment and the next one behind; in Aplodes, Synchlora, Zerene, Ennomos, etc., it has shifted back almost beneath the following segment.

Examples	**Brephinae**	Brephos nothum
	Hydriomeninae	Alsophila pometaria
		Hydria undulata
	Sterrhinae	Cosymbia lumenaria
	Geometrinae	Aplodes sp.
		Synchlora aerata
	Ennominae	Fidonia truncataria ?
		Zerene catenaria. Fig. 87.
		Lycia cognataria? Figs. 84 to 86.

and several other species unidentified.

Family Lacosomidae.

Prolegs with a complete circle of hooks, alternately of two lengths; body with four setae representing *vii* (the fourth one being probably *vib*) but otherwise without subprimaries; *iv* and *v* approximate below the spiracle, and on a level; all the setae clubbed; head Macro in its type of appearance; higher than wide; front rather high and extending half way to vertex; anal legs with a practically complete circle of hooks; labium with high narrow mentum, and rather small submenta, not meeting.

Example **Lacosoma chiridota,** halfgrown. Figs. 93, 94 and 95

Thaumetopoeidae.

Secondary hair on epicrania, front, adfrontals, mandibles, maxillae and labium, but not on clypeus or labrum. Front small; setae moderate, the punctures trisecting the space between the primaries; as wide as high, adfrontals narrow; labrum with a very shallow cleft, *iii* and *iv* distant, *vi* a very short distance from the margin. Prolegs with hooks all of the same length, in a single band, the anal prolegs with the same number of hooks (18) as the ventrals. Body with tufted hair, the tufts *ii*, *iii*, *iv*, and *vi*, as well as *vii* and *viii* of the legless segments, being distinct, the secondary hair is in two transverse bands. Tuft *i* is of short dense hair, making the caterpillar look like a Lymantriid. There are no eversible glands. True legs with very deeply and curiously cleft claws. The family is not American.

These characters suggest very strongly the Lymantriidae, especially Euproctis, without allowing one to deny that they may be due to divergence from a more primitive Notodontan origin. Staudinger and Rebel place it between the two families, which come together in their arrangement. It is usually considered Notodontid.

Example **Thaumetopoea** (of Europe). Figs. 96 and 97.

Lymantriidae.

With secondary hair on epicrania, adfrontals, maxillæ and labium, and sometimes on front, none on labrum, mandibles, etc.; front rather large, somewhat higher than wide, the punctures close together, the setae, when not obscured by secondaries, very high up and far apart; labrum quite variable; maxillæ and labium much as in the Noctuidae in form. Prolegs with a single band of hooks of a single length, the ventrals and anals equal. Body with tufted, but no secondary hair; wart *i* quite variable and furnishing generic characters, *viii* somewhat diffuse, as if there were a little secondary hair associated with it. Claws of true legs moderately cleft as in most Lepidoptera (similar to Fig. 101). Dorsal glands on 6th and 7th abdominal segments.

1. Labrum more deeply notched, one third its height or more, seta *vi* not on the margin, adfrontals enlarged at the top, with a tuft of secondary setæ; front and upper part of epicrania without secondaries.

2. Labrum cleft about half its height, setæ *i* and *ii* far out of line with each other; body with tufts *i* small, and *ii* moderate, both normal.

Example **Porthetria dispar.**

2. Labrum cleft about a third its height; setae *ii* only moderately out of line with *i*; body with tufts *i* and *ii* of four abdominal segments fused into large square masses.

Example **Hemerocampa leucostigma.** Fig. 98.

1. Labrum less deeply notched, *vi* nearly marginal; adfrontals slender, their secondary setæ inconspicuous; front with secondaries, especially in the lower part; epicrania with a good deal of hair above setae *ii*· warts *i* and *ii* of the first abdominal segments fused to each other, but not fused across the median line.

Example **Euproctis chrysorrhea.** Fig. 99.

NOCTUIDAE.

Prolegs with hooks in a single band, not alternately of two lengths. Usually without secondary or tufted hair, but both are present on the body in Pantheinae and Acronyctini; head with secondary hair on the epicrania, maxillae and labium in the Pantheinae only. Front large, more than a third of the height of the head above the clypeus, the frontal punctures usually close together, never nearer to the setae than to each other; labrum with puncture *ia* considerably nearer to *i* then to *ii*, not very high up; adfrontal puncture rarely more than twice as close to upper as to lower seta; maxillae and labium of about equal width; the submentum at least as wide as the base of the mentum, the labial setae *ai* close together. Setæ of abdomen all well separated, *i* somewhat higher than *ii*, *iv* higher than *v*, *vi* always single and *vii* with three setae except in forms with tufted hair; no caudal horn. In those with tufted hair there are four warts on thorax above the legs, on abdomen three above and two below the spiracle, besides *vii* and *viii*. Never with eversible dorsal glands; anal legs with more hooks than ventrals, one or two pairs of ventral legs often reduced or absent, but never three.

PANTHEINAE: Epicrania, maxillae and labium with considerable secondary hair; adfrontals wide above the top of the front, the puncture about half way between the setae, and above the top of the front. Body with tufts and pencils, with secondary hair also, in Panthea.

Example **Demas coryli.** Figs. 100 and 101.

NOCTUINAE: Head without secondary hair, body occasionally with tufted and secondary hair, or tufted hair only. Adfrontal puncture below the top of the front, and adfrontals rarely much widened at the top (Apatela interrupta); anal legs directed downwards and not lengthened; setae usually short except in hairy forms, distance between upper adfrontal setae less than half height of front; distance between frontal punctures not less than a third that between seta and puncture.

In this group of Noctuinae (or Trifidae) there is a good deal of minor variation between different genera, and even species of the same genus, but my series of forms, though larger than of any other family so poorly represents this enormous group that I shall only characterize the two tribes *Acronyctini* and *Cuculliini* (Cuculllianae of Hampson) and mention a few peculiarities of some other genera.*

* I have done nothing whatever with the body setae. Dyar discusses seta iv in Proc. Ent. Soc. Wash. IV, 370 and Bird, in Can. Ent. Vols. 32–34, 39, 40 refers often to variations in the tubercle of the genus Papaipema. See also my "Field Tables," page 140.

Acronyctini: with several-haired warts and often with secondary hair; with fine setiform granulations, with which there may be mixed larger conical ones. Epicrania high, extending over 1 1-3 times the height of the front above its top; adfrontals very wide, the upper setae far apart and high above the top of the front; clypeal setae closer together than the frontal seta and puncture; *i* and *ia* of labrum separated by a distance less than the width of a setigerous puncture; last joint of maxillary pulpus short.

With secondary hair; labrum more deeply notched, *iii* and *iv* of labrum well separated, head dark, front about as wide as high, setae *i* and *ii* of labrum form an angle of about 60 degrees with the horizontal. Adfrontals not especially wide at the top of the front.

Examples **A.** (**Hyboma**) **hasta.** Fig. 103.
A. (**Triaena**) **hastulifera.** Fig. 102.

Similar; adfrontals with an enlargement at the top of the front, which contains the setae and puncture; labral notch not so deep.

Example **A.** (**Triaena**) **occidentalis** (**interrupta**).
Figs. 1, 12 and 26.

Similar; head pale, labral notch shallower; front narrow; adfrontals unusually high and yet narrow; clypeal setae closer together; setae *i* and *ii* in a line only 30 degrees from the horizontal; *ia* distant from *i*.

Example **A.** (**Acronycta**) **leporina.** Fig. 105.

No secondary hair, labrum deeply notched; head black; front narrow; *iii* and *iv* of labrum obliquely placed, separated by only half the vertical distance that separates *i* and *ii* horizontally.

Example **A.** (**Eulonche**) **oblinita.** Fig. 104.

No secondary hair; labrum notched only 1-4 its height; front wide.

Example **Simyra** (**Arsilonche**) **henrici.** Fig. 106.

In the remaining forms there is no tufted or secondary hair; there are no fine setiform granulations, though there may be coarse ones; the front is larger in proportion to the epicrania and to the adfrontals; the adfrontal setae are closer to the front and to each other; *i* and *ia* of labrum are more widely separated.

Cuculliini Clypeal setae closer together than the distance between frontal seta and puncture, epicrania not reduced, labral setae about evenly spaced.

Adfrontals *i* level with top of front; clypeal setae much closer together than frontal seta and puncture; labral setae *i* and *ii* quite evenly spaced; front as wide as high; adfrontals narrower; setæ of labial palpi long.

Example **Cucullia** sp. (undescribed). Fig. 110.

Adfrontal setae *i* higher, clypeal setae farther apart; labral setae distinctly arranged in pairs; front narrow, adfrontals wider; setae of labial palpi minute.

Example **Scopelosoma** sp.

Adfrontals *i* high, clypeal setae much closer together than frontal seta and puncture; labral setae *i* and *ii* distinctly arranged in pairs; front distinctly higher than wide; setae of palp intermediate.

Example **Calocampa curvimacula.**

Earias chlorana (of Europe) is made the type of a subfamily or placed with Nycteola. Claw very deeply notched; second joint of antenna short, tubercles *ii* of 8th abdominal segment enlarged, and also *ib* of thorax; *ii* of epicrania directly below *i* and close to edge of adfrontals (as in some Micros) front a nearly equilateral triangle, adfrontals quite broad, and rather ill-defined; upper ocellus behind second instead of being above it. Fig. 112.

Rhodophora. Skin coarse and granular (Fig. 138), the coarser granules much more prominent than in Feltia; frontal punctures trisecting the space between the setae; punctures of adfrontals half way between the setae; labrum hardly notched, with setae *i* and *ii* in a straight line. The granular skin occurs also in Heliothis.

Nectua Labrum with setae *iii* and *iv* on a level, prolegs with 40 hooks. (c-nigrum and other unidentified species.)

Feltia. Coarse nodular granulations; first prolegs reduced to half their normal number of hooks and second prolegs slightly reduced; epicrania very low, in the last stage the adfrontals reach the vertex in a way similar to Zygaena. (Three stages). Fig. 108.

Prolegs with only 10 crotchets; epicrania very short; adfrontal punctures half way between the setae. An unidentified species, agreeing with Slingerland's description of Euxoa scandens. Fig. 109.

Hadena (*Trachea*) *turbulenta.* Outer margin of front very sinuous. Fig. 107.

In *Pyrophila pyramidoides*, *Ceramica picta* and two species of *Leucania*, there were no decided characters. The epicrania were a little larger than in the preceding genera.

NYCTEOLINAE: Considered the type of a distinct family by some. Epicrania extending above top of front 1 1-2 times its height; *ep. ii* nearly twice as close together as *i*, yet distant from the adfrontals; labial palpi long and slender; adfrontals broad and ill defined outwardly; ocelli small, the distance between two ocelli being much more than the width of an ocellus. Body-hair long and fine.

Example **Nycteola revayana.** Fig. 111.

CATOCALINAE: Like the Noctuinae, but with the anal legs lengthened, or produced backward; head sometimes held horizontally; never with tufted or secondary hair.

Hind legs not lengthened; prolegs with about 25 hooks; setae *i* and *ii* of labrum at an angle of 30 degrees to the horizontal, *iii* and *iv* obliquely placed and close; epicranial setae *ii* low opposite *adf. i* and distant from *ep. i.*

Example **Ingura** sp.

Anal legs somewhat lengthened, prolegs with about 25 hooks; setae *i* and *ii* of labrum nearly on a level; *iv* higher than *iii*; the two upper ocelli in contact; *ep. i* and *ii* close together near vertex; epicrania extending less than its height above its top.

Example **Drasteria erechtea.**
D. crassiuscula.

Anal legs very long and produced backward, head held horizontally; 45 hooks on prolegs; labrum with setae *i* and *ii* nearly on a level, *iii* and *iv* close, *iii* directly above *iv*; frontal punctures less than twice as close to each other as to the setae; notch of labrum rather shallow; clypeal setae much farther apart than frontal seta and puncture; *ep. i* and *ii* close together on the face. (The conical hump of C. cara lines between them.)

Example **Catocala cara.** Figs. 2 and 3.

Anal legs very long; prolegs with over 50 hooks; labrum with setae *i* and *ii* at an angle of over 45 degrees; *iii* and *iv* distant, frontal punctures decidedly closer together, frontal setae high up; labrum deeply notched; *ep. i* and *ii* close together near vertex.

Example **Panapoda rufimargo.**

HYPENINAE (Deltoides); Setae long and stout, both on head and body; distance between adfrontal setae *i* more than half height of front, and they are also high up; distance between frontal punctures hardly more than 1-4 that between puncture and seta; front small, its setae usually high.

Slender, green, a semilooper with only 14 legs, anal legs produced backward as in Catocala.

Example **Hypena humuli.**

ARCTIIDAE.

Head usually with sparse secondary hair on epicrania, front and maxillae, often also on labium; none on clypeus, labrum, mandibles antennae, etc., or body, rarely on adfrontals (Apantesis). Epicrania rounded, front large, with the punctures about as far apart as the distance between a puncture and a seta; labrum normal, *vi* nearly marginal, puncture usually very high up, and more nearly over *ii* than *i*: adfrontals usually very narrow and irregular, with the puncture close to the upper seta. Maxillae usually somewhat narrower than labium, the base of the mentum about twice as wide as one of the submenta. Body without secondary, but with tufted hair; four warts above legs on thorax, and three above spiracle on abdomen,—all the tubercles below the spiracles developed as separate warts.

LITHOSIINAE: Head without secondary hair, adfrontal puncture close to upper seta; hair not feathered; no pencils or dense dorsal tufts; adfrontals very narrow and wavy-edged; thorax with the two upper warts side by side as on the abdomen. Frontal punctures twice as close together as distance between puncture and seta.

Example **Lithosia complana.**

ARCTIINAE: Head with secondary hair (except Euchaetias, in which the adfrontals are quite wide); hair serrate or feathered on body; often with dense pencils and dense dorsal tufts; warts of thorax all in a vertical line. Punctures of front nearly trisecting the distance between the setae.

Adfrontal punctures about a third way down from upper seta, adfrontals broader; warts *i* and *ii* of abdomen transversely elongate and side by side, bearing dense tufts; with pencils of hair, hair very feathery. Labrum with puncture rather near to setae as in the Noctuidae (When young the puncture is a little nearer to the normal Arctiid position). Frontal punctures decidedly below the level of the setae.

Examples **Halesidota caryae.** Figs. 119 and 120.
H. maculata.
H. tessellaris.

Adfrontal puncture near upper seta; adfrontals, warts and hair suggesting Halesidota; head without secondaries (when very young the warts are as in normal Arctiidae, rather than as in Halesidota). Frontal setae and punctures on a level.

Example **Euchaetias egle.** Figs. 117 and 118.

In the remaining genera the hair is serrate rather than feathery, without dense tufts or pencils; puncture *ia* of the labrum at least as far from *i* as *ii* is; epicrania and maxillae, at least, with secondary hair. Frontal setae and punctures nearly on a level.

Front, labium and maxillae each with several secondaries; an anal tuft of long hair.

Example **Eubaphe nigricans.**

Front with several secondaries: maxillae with about ten secondaries, labium with a single pair; some scattered long hair.

Example **Hyphantria textor.**

Front, adfrontals, and maxillae each with several secondaries, labium without any; adfrontal punctures about a third way down from the setae; no long hair.

Example **Apantesis parthenice** (?) young. Figs. 113 and 116.

Front without secondaries, labium with a single pair, maxillae with about six. Frontal puncture and seta closer together than clypeal setae.

Example **Diacrisia virginica.**

Front with or without secondaries (at most a single pair); maxillae with five secondaries, labium with none; clypeal setae as in the last; no scattered longer hairs.

Example **Isia isabella.** Figs. 114 and 121.

Front without secondaries, stipes with six or seven; clypeal setae nearer together than frontal seta and puncture.

Example **Estigmene acraea.**

Syntomidae.

Prolegs with hooks in a single band, all of the same length. Head with secondary hair on epicrania, front, maxillae and labium, but not on adfrontals, clypeus, labrum, mandibles, etc.; body with tufted hair. Front quite small, the epicrania extending fully twice its height above its top; frontal setae rather close together; adfrontal setae and puncture close together, the puncture almost as near the lower as the upper seta. Labrum with puncture *ia* decidedly nearer *i* than *ii;* labium short and broad, the submenta separated by more than their width at the base. Thorax with only three tufts above the legs, the upper one twice as large as normal and elongate; abdomen with tufts as in the Arctiidae, *i* forming pencils.

Example **Ctenucha virginica.** Fig. 122.

Zygaenina.

Head retracted within the first segment of the body; epicrania with setae reduced; the vertex cleft nearly to the top of the front, or with the cervical skin attached to the epicrania along a similar line; front triangular, about as high as wide, the adfrontals narrow and not extending much above it; frontal punctures about trisecting the distance between the setae, a little farther apart in Zygaenidae; clypeus with setae rather far apart, labrum with *i* no higher than *ii;* mandible with setae close together; maxilla with seta *iv* distinctly arising from the galea, submenta about as wide as base of mentum, or membranous and indistinct; sclerite *b* of labium broad and massive as in the butterflies. Body with *iv* and *v* approximated, or forming the same wart, *i* and *ii* separate or forming the same wart; with tufted or secondary hair,

or with primary hair only, when there is tufted hair there are only two warts on the abdomen above the spiracle. Prolegs with hooks not alternately of the two lengths, or without prolegs.

HETEROGYNIDAE: With primary hair only; prolegs with a single normal band of hooks; head black and heavily chitinized; epicrania with a deep cleft at the vertex; front with the punctures decidedly nearer the corresponding setae, than to each other; labrum with *ii* strong, and no higher than *i*: antenna normal; body with *i* and *ii* well-separated, *iv* and *v* approximated, two setae on a level, in the position of *vi*, but one on the outer side of the proleg, and two on the inner side. It seems clear that the anterior seta on the inner side of the proleg belongs to *vii*, but more doubtful whether the additional seta in the position of *vi* is the other missing one.

Example **Heterogynis paradoxa.**

ZYGAENIDAE: Head as in the preceding, seta *ii* of the labrum decidedly higher than *i*, but fully developed; body with somewhat diffuse tufts of hair, representing, *i+ii*, *iii*, *iv+v*, *vi*, and two tufts representing *vii; viii* single-haired; hair serrate, but not feathery.

Example **Zygaena trifolii.**

MEGALOPYGIDAE: Head pale, and lightly chitinized, submenta membranous; epicrania with the cleft in the vertex filled up, apparently by the growing together of its edges; their setae rudimentary; labrum with *ii* higher than in Zygaenidae, much smaller than *i*, none of the setae marginal; frontal punctures rather nearer to each other than to the corresponding setae; antenna with first joint about as long as second, second less than twice as long as wide and without any long seta. Body with tufts as in Zygaenidae, but in addition with two isolated setae on a hump, near the tip of the prolegs. The row of hooks on the ventral prolegs is angulate in the middle and the shortest hooks come next to the angle. *viii* is opposite the apex of the angle. Second and seventh abdominal segments with rudimentary prolegs, on which the setae are arranged as on the normal ones, but without any hooks.

Example **Lagoa crispata.** Figs. 123, 124, 125, 126 and 135.

EUCLEIDAE: Mostly like the preceding family. Hair more or less reduced, diffuse, modified into branching spines, or absent;* without prolegs, and without setae on the ventral part of the body; with a row of ventral suckers.

Examples **Cnidocampa flavescens.**
Empretia stimulea.
Euclea delphinii.

NOLIDAE.

With tufted, but no secondary hair. Epicrania, front and clypeus as in the Eucleidae, but with normally developed setae. Labrum with setae normal, *i* lying between setae *ii*, and nearly on

* See Dyar, Journ. N. Y. Ent. Soc., vols. iii to vii for details of structure of the various species.

a level with them; basal joint of antenna nearly as long as second joint, which is short, submenta heavily chitinized and well separated. Body with tufts representing *i + ii*, *iii*, *iv + v*, *vi*, *vii*, and *viii*, with only two, therefore, above the spiracles, while there are three in the Arctiid types. Prolegs with a single uninterrupted row of hooks, all of the same length; no prolegs on third segment of abdomen.

Example **Nola cucullatella.**

Psychidae.

Prolegs with hooks all the same length, in a circle broken posteromesally; anal legs similar to the others. Adfrontals massive, their setae well separated, not reaching far above the top of front; *ii* of epicrania close to them; frontal setae far apart, punctures close together and somewhat lower; antennae normal with short second joint; prothoracic spiracle piercing the cervical shield; labrum with *vi* not on the margin. Mera of true legs much enlarged and nearly or quite meeting in the middle line; all segments of the thorax with dorsal plates. Body with setae *i* and *ii* variable, *iv* and *v* close together, *vii* variable, *ii* of ninth abdominal segment distant from each other.

Solenobiinae: True legs very long, and slender; front twice as high as wide; abdomen with *ii* lower than *i*, normal; prolegs with about 15 hooks.

Example **Solenobia pineti.**

Psychinae: True legs short and very stout; front shorter; abdomen with *ii* higher than *i*: prolegs with over 20 hooks.

Front nearly as wide as high; *ii* of abdomen almost directly over *i*;
Example **Thyridopteryx ephemeraeformis.** Figs. 128 and 134.

Front half higher than wide; *ii* of abdomen on the next annulet behind *i*.
Example **Psyche zelleri.** Fig. 127.

Cossidae.

Prolegs with hooks in an uninterrupted circle, alternately of three lengths, but with no great difference between the three lengths; the anal legs with hooks in a curved band. No secondary or tufted hair. Epicrania separated by a membranous area at the vertex, a slender prolongation of the adfrontals reaching the vertex; head not retractile. Front higher than wide; the setae far apart and the punctures close together, level with the setae. Adfrontals large, reaching vertex, the setae rather close together, opposite the upper half of the front. Labrum with a shallow notch, *i*, *ii*, *iii*, and *iv* nearly on a level, none of the setae quite on the margin; mandibles extend forward with the cutting edge turned upward for gnawing wood. *Maxillary palpi with second joint very wide and massive, bearing the large cones, which turn inward* as in the Hepialidae; the galea arises from its apex as in other Frenatae, and is quite small. Labium normal with sclerites *b* massive, and *c* slender; palpi rather short; submenta not in contact. Prothoracic spiracle distant from cervical shield; body with setae as in

the Tortricidae; but on a9 the tubercles *ii* are not fused across the middle line.

In the structure of its lower lip this family is very different from the Tortricidae, and may be the most primitive of the Frenatae.

Example **Cossus cossus** (three stages). Figs. 129, 130 and 131

ÆGERIIDAE (SESIIDAE).

No secondary hair; prolegs with hooks in two curved transverse lines, all of the same length, anals rudimentary, with few hooks. Epicrania low, with *ii* rather near the adfrontals, adfrontals practically reaching vertex, their setae close together near the middle, puncture opposite upper seta; front high and lanceolate, setae high, punctures low and not very close together; clypeal setae well separated. Labrum normal; maxillae with large cones part way down the inner side as in Hepialus, but galea arising from second joint of palpus as in Frenatae. Basal joint of antennae massive. Body with *iv* and *v* fused, *vii* is a vertical row of three setae, the middle one the longest. Last spiracles dorsal and higher than *iii;* setae *ii* of A9 separate.

Example **Melittia cucurbitae.** Fig. 132.

MICROLEPIDOPTERA.

As my series of Microlepidoptera is quite short, it does not seem best to discuss the families separately.

Setae *ii* of the epicrania are usually rather close to the adfrontals, as in Argyresthia, but often somewhat more distant. They are never as far away as in the Bombycid series. The front is usually much higher than wide, often twice as high, but in *Endrosis* it is not, and in the *Pyralidæ* there are various intermediate conditions. When the front is high, the adfrontals nearly or quite reach the vertex, but when it is lower the adfrontals may merely border it, as in most Macrolepidoptera. The frontal setae are often far apart, close to the outer edge, as in *Depressaria* and *Homoeosoma*, or they may be closer together, but are never very close, as in the Bombycid series and Zygaenina. In the lower forms the punctures trisect the distance between them, but in the *Tortricidae*, *Pyralidae*, *Depressaria*, *Simaethis*, etc., they are much closer together, and lower, as in the Noctuidae. The adfrontal setae are very close together in *Gracilaria*, but often are not so. The puncture is apt to be about half way between the setae. The labrum is usually not very deeply notched, its setae *i* and *ii* nearly on a level.

The antennae are normal, but often with a seta on the side of the second joint, as in *Yponomeuta* and *Cacoecia*, figured. *Yponomeuta* is very aberrant in the proportions of the joints. The maxillae and labium are rather long, with the sclerites tending

to be well-developed, the maxilla with stipes, palpifer and subgalea sometimes separately chitinized, the submenta not widely separated, or even in contact, (Fig. 137). Setae of mentum rather nearer the base than is typical of the Macrolepidoptera.

There is never secondary hair on the head, and secondary and tufted hair on the body only in the *Pterophoridae*.

Thorax with cervical shield well developed—in the lower forms with additional sclerites ventrally and laterally, which reach their greatest development in *Adela* (Fig. 6). The true legs are absent in *Nepticula*, replaced by patches of enlarged granulations similar to those representing the prolegs.

Abdomen usually with anal plate only, but with two dorsal and two ventral plates on each segment in *Incurvaria*. Setae *i* and *ii* well separated except in the Pterophoridae, *iv* and *v* approximated, except in *Yponomeuta*, where they are distant and *iv* is higher than *v*, they are usually on a single tubercle, and *iv* may be much reduced. *vii* is quite variable, most often in the Tortricidae the setae form an oblique line, while in the Tineina the middle one is anterior. In the *Pterophoridae*, *Thyris*, and *Simaethis* they lie, not on the leg, but on a plate at its base. *Adela* and *Incurvaria* are somewhat different (Figs. 34 and 35). *viii* lies on the anterior side of the leg in *Adela* and *Incurvaria*. On the ninth abdominal segment setae *ii* are both on a single median tubercle in the *Tortricidae*, but in the others they are distinct, and often distant.

The hooks of the prolegs in the Pyralididae and Tortricidae are oftenest in a complete circle, alternately of two or three lengths. They are similar in *Thyris*, *Endrosis* and *Depressaria*. Most Tineidae, as well as *Phalonia* and *Orneodes*, have but a single length. In *Gracilaria* there is half of a second band (Fig. 7). *Adela* has two areas of minute hooks, grading into the granulations, which in Incurvaria are reduced to a single transverse row. *Yponomeuta* has three or four complete circles of hooks. *Nepticula* would appear to have the hooks replaced by a vague area of enlarged conical granulations. In *Panorpa*, there is such an area of enlarged, but setiform granulations, on the posterior side of each of the slender prolegs.*

Tineola resembles Solenobia in its head and ventral prolegs, but its anal prolegs are normal.

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*I am indebted to Dr. E. P. Felt and Prof. J. H. Comstock for the loan of this specimen from the Cornell University collection.

The anal prolegs are wanting in *Adela* and *Incurvaria*, those of the sixth abdominal segment are absent in *Gracilaria* and *Coleophora*, and reduced in *Adela*.

Examples:

Thyris vitrina.
Oxyptilus hieracii.
Botys polygonalis.
Hydrocampa nymphaeata.
Homoesoma nebulella.
Crambus falsellus.
Galleria mellonella.
Orneodes hexadactyla.
Cacœcia cerasivorana. (Figs. 133 and 137).
Carpocapsa pomonella
Several other unidentified Tortricidae.
Phalonia alcella.
Yponomeuta cagnagellus. (Fig. 141).
Simaethis oxyacantha (Figs. 139 and 140.)
Argyresthia goedartella (Fig. 136.)
Sitotroga cerealella.
Depressaria putridella (Fig. 142).
Cosmopteryx scribaiella.
Coleophora.
Endrosis lacteëlla (Fig. 143.)
Gracilaria alchimiella. (Fig. 7.)
Nepticula pomivorella.
Tineola bisselliella.
Incurvaria koerneriella. (Fig. 34.)
Adela degeerella (Figs. 6 and 35.)

Summary.

1. Useful classificatory characters may be found in the structure of the sclerites of the caterpillar head, and the arrangement of their setae.

2. The Sphingidae, Saturniina, Bombycidae, Notodontidae and, perhaps the Lacosomidae, with their related families, show positive points of resemblance, aside from the mere presence of secondary hair in most of them. This is found in the prolegs, subprimary setae, frontal setae and proportions of front and head, and in their habits.

3. The genus *Apatelodes* is a synthetic form with suggestions of Lasiocampidae, Saturniidae, Bombycidae and perhaps Sphingidae. It is not near the Notodontidae. Melalopha is a fairly typical Notodontid.

4. *Lacosoma* is a synthetic form between the Microlepidoptera and Bombyx-Notodontid series, nearer (at least when young) to the Microlepidoptera.

5. Some *Papilios* have the proleg structure of the skippers and Microlepidoptera. It is correlated with a nestbuilding habit.

6. Thyris is a typical Microlepidopter.

7. Cast skins and specimens dried without preparation make fairly satisfactory material for study, thus making it possible to found complete descriptions of larvae on the identical specimens that are bred through and accurately named.

Bibliography.

Edwards, Henry, Bibliographical Catalogue of the Described Transformations of North American Lepidoptera. Bulletin of the United States National Museum, No. 35; Washington, 1889.

A list of references to descriptions of North American Caterpillars, complete to its date.

Dyar, H. G. A List of North American Lepidoptera, and Key to the Literature of this Order of Insects. Bulletin No. 52 of the United States National Museum, Washington, 1902.

Refers to the Bibliographies of American Lepidoptera.

Descriptions of Caterpillars.

(Only a few of the most important titles are given, see Edwards, cited above)

Lepidoptera.

Buckler, W., The Larvae of the British Butterflies and Moths; edited by George T. Porritt. London. Completed in 1901.

Contains 154 plates, illustrating very fully the British caterpillars, but with comparatively little descriptive matter.

Hofman, Ernst, Die Raupen der Grossschmetterlinge Europas; Stuttgard, 1893.

Describes and figures the known European Macrolepidopterous caterpillars. 50 plates.

Forbes, Wm. T. M., Field Tables of Lepidoptera, Worcester, 1906.

Contains an analytical key to the better known macrolepidopterous caterpillars of Eastern North America, arranged artificially for convenience in identifying specimens; also their foodplants; and the dates of appearance of a number of the more generally interesting ones.

Rhopalocera.

Scudder, S. H., The Butterflies of the Eastern United States and Canada, Cambridge, 1889.

A mongoraph, as complete as it could be made. Colored plates.

Edwards, W. H., Butterflies of North America, Boston and New York. Completed in 1987.

Sphingidae.

Fernald, C. H., The Sphingidae of New England. Orono, 1886.

Describes the species then known, and gives a few figures.

Eliot, Ida M. and Soule, C. J., Caterpillars and Their Moths, New York, 1902.

Although popularly written, this is the authority to go to for the sphinx caterpillars of Eastern North America. Photographs.

Rothschild, W., and Jordan, K., A Revision of the Lepidopterous Family Sphingidae. Novitates Zoologicae, Supplement to vol. ix., Tring, 1903.

Describes the known caterpillars of the world, and makes a slight attempt to classify them. Bibliography.

Ceratocampidae.

Packard, Alpheus S., Monograph of the Bombycine Moths, Part II. Memoirs of the National Academy of Sciences, vol. ix, Washington, 1905.

A monograph of the family for North America; with colored plates.

Notodontidae.

Packard, Alpheus S., Part I of the same. Memoirs of the National Academy of Sciences. Vol. vii, Washington, 1895.

A monograph of the family in North America north of Mexico. Colored Plates.

Syntomidae, Arctiidae and **Noctuidae** in part.

HAMPSON, GEORGE F., Catalogue of the Lepidoptera Phalaenae in the British Museum. London, nine volumes published so far.

Long descriptions by Dyar of the North American caterpillars, and briefer ones by the author, of those of other parts of the world.

Noctuidae.

SMITH, J. B., and DYAR, H. G., Contributions toward a Monograph of the Lepidopterous Family Noctuidae of Boreal North America; A Revision of Acronycta (Ochsenheimer) and of Certain Allied Genera. Proceedings of the United States National Museum xxi, 1; Washington, 1898.

Describes and gives a key to all the species, and figures many of them. There is also a discussion of the setae as a means of classification.

DYAR, H. G., Descriptions of the Larvae of Fifty North American Noctuidae. Proceedings of the Entomological Society of Washington, iv, 315; Washington, 1899.

An artificial key to the species described.

Geometridae.

PACKARD, A. S., A Monograph of the Geometrid Moths, or Phalænidæ, of the United States. United States Geological and Geographical Survey of the Territories, Report, vol. x, Washington, 1876.

Describes the species then known, and figures many; now more or less out of date.

DYAR, H. G., Life-Histories of North American Geometridae. Psyche, Cambridge, vols. ix to xiv, 1900 to 1907.

Gives descriptions of all the stages of the caterpillars studied, with their superficial structural characters. There is little or nothing about their life history proper.

Eucleidae.

DYAR, H. G., and MORTON, E. L., The Life-Histories of the New York Slug-Caterpillars. Journal of the New York Entomological Society, vols. iii to vii, New York, 1895 to 1899.

Monographs, with colored figures, of the eighteen New York species. Important discussions on setae and skin granulations. In the same place Dyar describes several exotic slug-caterpillars also.

DYAR, H. G., Annals of the New York Academy of Science, viii, 193.

Cited under "Setae," below. It summarizes the structure of the Eucleid larvae, species by species, paying especial attention to the setae.

Pyralididae, Crambinae.

FELT, E. P., On Some Grass-eating Insects. Ithaca.

Descriptions and Life Histories.

FERNALD, C. H., The Crambidae of North America, Boston, 1896.

Contains about the same material.

Nymphulinae.

DYAR, H. G., The North American Nymphulinae and Scopariinae. Journal of the New York Entomological Society, xiv, 77; New York, 1906.

Sesiidae.

BEUTENMULLER, WM., Monograph of the Sesiidae of North America north of Mexico. Memoirs of the American Museum of Natural History. Vol. I, part vi, 217, New York, 1900.

The descriptions of the caterpillars by Dyar are unusually complete. Keys arranged by structure and by food-plant.

STRUCTURE.

General Anatomy.

LYONNET, PIERRE. Traite Anatomique de la Chenille qui Ronge le Bois de Saule. La Haye, 1760.

This contains the only accurate figures I have seen of caterpillar mouth-parts. Also a full description of the external and internal anatomy of Cossus cossus. A couple of figures from it are copied on plate 10.

Prolegs.

SUNDEVALL, CARL J., Om Msekternas Extremiteter samt deras Hufvud och Mundelar. Till K. Vet. Akad. Inlemnad d. 11 Januari, 1860.

Figures caterpillar mouth-parts and legs.

GOOSSENS, TH., Les Pattes des Chenilles. Annales de la Societe Entomologique de France, vii, 385, Paris, 1887.

He has a pretty series of figures of the true legs as well as the prolegs, but unfortunately it is a very superficial study.

CHAPMAN, T. D., On Some Neglected Points in the Structure of the Pupae of Heterocerous Lepidoptera and Their Probable Value in Classification; with some Associated Observations on Larval Prolegs. Transactions of the Entomological Society of London, 1895. 97 to 119, London.

Refers more especially to the presence of a complete circle of crotchets in the lower forms.

Setae.

DYAR, HARRISON G., A Classification of Lepidopterous Larvae. Annals of the New York Academy of Science. viii, 194 to 232, New York, 1895.

Although he has led up to it in a couple of descriptions in Entomologica Americana, this paper of Dyar's is really the pioneer work on caterpillar setae as a means of classification. A large number of caterpillars are discussed from this point of view. Figures.

DYAR, Additional Notes on the Classification of Lepidopterous Larvae. Transactions of the New York Academy of Science xiv, 49 to 62, New York, 1895.

Additions and corrections to the last, with more attention to the first stage.

PACKARD, A. S., Monograph of the Bombycine Moths, I. See above under "Notodontidae."

PACKARD, A. S. On a New Classification of the Lepidoptera. American Naturalist, xxix, 636, Philadelphia, 1895.

Gives figures of the mouthparts of Eriocephala (Jugatae).

DYAR. A Classification of the Lepidoptera on Larval Characters. American Naturalist. xxix, 1066 to 1072, Philadelphia, 1895.

Discusses especially the Jugatae, with figures of Hepialus, Micropteryx and Eriocephala.

DYAR. On the Larvae of the Higher Bombyces (Agrotides Grote). Proceedings of the Boston Society of Natural History xxvii, 227, Boston, 1895.

Gives the structural characters of a large number of forms, of the following families. Drepanidae, Apatelidae (Noctuidae in part), Arctiidae, Nolidae, Lithosiidae, Euchromiidae, Eupterotidae (no typical species), Lemoniidae, Lymantriidae, Lasiocampidae, etc. There is also a genealogy and a key to the families.

DYAR. The number of Stages in Apatelodes torrefacta. Psyche, vii, 316, 1895. Cambridge.

With a description and figures of the seta-plan of the first stage.

DYAR. Note on the Head-Setae of Perophora melsheimerii. Journal of the New York Entomological Society, iv, 92, New York, 1896.

Figures the head, numbering the epicranial setae.

TUTT, J. W. A Natural History of the British Lepidoptera. London, 1900.

A chapter on caterpillar anatomy with a long discussion of the setae.

Most of Dyar's descriptions of caterpillars contain more or less in reference to their setae. In particular the following may be mentioned:

Journal of the New York Entomological Society iii, 68 (Eudeilinea) iii, 17 (Thaumetopoea), iii, 130; iv, 68 (Pericopidae).

Canadian Entomologist xxvii, 325; xxvii, 159 (Apatelodes); xxviii, 2; xxviii, 103.

Entomological News vi, 38 to 40 and 100. (Pterophoridae).

Psyche vii, 259 (Clisiocampa).

EXPLANATION OF THE FIGURES.

PLATE X.

FIG. 1. Front view of head of caterpillar (Apatela), with setae numbered.
adf., adfrontal sclerite; *adf. i*, *adf. ii*, its setae.
adf. o., adfrontal puncture.
fr. i, frontal setae. *fr. o.*, frontal puncture.
cl. i., and *cl. ii.*, clypeal setae.
lbr., labrum.
ant., antenna.
md., mandible. *md. i.* and *md. ii.* its setae.
i to *xi*, setae of epicrania.

FIG. 2. Under lip of caterpillar (Catocala).
S. m., Submentum.
Ment., Mentum.
m. i., mental seta.
c., Cardo.
St., Stipes.
i and *ii*, Setae of stipes.
iii, Seta of first joint of maxillary palpus.
mx. p., Free part of maxillary palpus.
(See also Figures 3 and 26.)

FIG. 3. Tip of labium of Catocala.
Seta of sclerite *a*.
a. i. b., Sclerite *b*, perhaps the palpifer.
b. o., Punctures of sclerite *b*.
c. o., Puncture of sclerite *c*.
seg. 1, *Lb. p*, *seg.* 3, The three joints of the labial palpus.
Sp. Spinneret.

FIG. 4. Seta plan of a typical (Noctuid) caterpillar; metathorax. In these diagrams a single segment is represented as if cut on the mid-dorsal and mid-ventral lines, and laid flat. The anterior edge is to the left, and the mid-dorsal line at the upper edge.

FIG. 5. Seta plan of a middle abdominal segment of the same type.

FIG. 6. Proleg of Adela, with the setae numbered, ventral view.

FIG. 7. Proleg of Gracilaria, lateroventral view.

FIG. 8. Proleg of Noctuid caterpillar, lateral view; seta viii is shown in dotted lines as if seen by transparency, and the roots of the hooks are represented in the same way.

FIG. 9. Arrangement of hooks on the proleg of a Sphingid or Bombycid caterpillar.

PLATE XI.

FIG. 10. Proleg of Papilio polyxenes, somewhat flattened; seen from the median side.

FIG. 11. Proleg of Jasoniades glaucus, split down the side to the planta and flattened out.

FIG. 12. Labrum of Acronycta, showing typical arrangement of setae, and one of the punctures.

FIGS. 13 to 24. Labra of butterflies; drawn to the same scale.

13.	Anosia plexippus.	19.	Cercyonis alope.
14.	Argynnis cybele.	20.	Pieris rapæ.
15.	Euphydryas phaeton.	21.	Papilio polyxenes.
16.	Polygonia interrogationis	22.	Jasoniades glaucus.
17.	Euvanessa antiopa.	23.	Epargyreus tityrus.
18.	Basilarchia disippus.	24.	Pholisora catullus.

FIG. 25. Labium of an Elater beetle larva (compare with Figs. 2 and 32).

PLATE XII.

FIG. 26. Tip of left maxilla of a Noctuid caterpillar, caudal aspect.
iv and *v*, setae of second segment of palpus.
palp. 1, First free segment of palpus.
2, Second free segment of palpus.
base, Basal segment of galea.
mx. l., Maxillary lobes.
l. c., Inner large cone, the outer one is behind the outer maxillary lobe.
st. c., Step cone.
s. c., Small cone. The inner one is in front of the inner maxillary lobe.
FIG. 27. Tip of maxilla of Hepialus (Jugatae), caudal aspect.
FIG. 28. A typical mandible (Phlegethontius quinquemaculatus, side view of right mandible).
FIG. 29. A typical antenna (Diacrisia virginica), side view of right antenna. (The long seta is posterior).
FIG. 30. Arrangement of eyes of right side in the Jugatae (Hepialus hectus).
FIG. 31. Arrangement of eyes of right side in the Frenatæ (Demas coryli).
FIG. 32. Maxilla and labium of a sawfly. The right maxilla is not shown. The part of the maxilla covered by the labium is indicated in dotted lines.
FIG. 33. Seta plan of middle abdominal segment of Hepialus hectus; compare Figs. 4 and 5.
FIG. 34. Same of Incurvaria, showing also the dorsal and ventral sclerites.
FIG. 35. Ventral view of pro- and mesothorax of Adela.
St., Sternum.
Cx., Coxa.
F., Femur.
T., Tibia.
tr., Trochanter.

PLATE XIII.

FIG. 36. Labium and maxillae of Basilarchia disippus. The drawings of lower lips were made with the camera lucida, and they are drawn as they appeared in the prepared specimens. They are usually somewhat retracted, on one or both sides. In life the labium is usually folded so that the spinneret lies at right angles to the rest, and the base of the spinneret and the setae *ai* at least, are concealed.
FIG. 37. Labrum of Libythea celtis, on the same scale as the other butterfly labra.
FIG. 38. Labrum of Thella ilicis.

SPHINGIDAE.

FIG. 39. 40 and 41. Head, labrum and lower lip of Dolba hylaeus (?).
FIG. 42. Sketch of head of Paonias myops, to show the form.
FIG. 43 and 44. Front and labrum more enlarged.
FIG. 45. Head of Ceratomia amyntor.
FIG. 46. Head of Deilephila gallii.
FIG. 27. Head of Pseudosphinx tetrio.

PLATE XIV.

FIG. 48 and 53. Head and labrum of Amphion nessus.
FIG. 49. Labrum of Ceratomia amyntor.
FIG. 50. Labrum of Pseudosphinx tetrio.
FIG. 51. Labrum of Phlegethontius carolina.
FIG. 52. Labrum of Deilephila gallii.
FIG. 54, 55 and 56. Head labrum and lower lip of Apatelodes torrefacta.

ENDROMIDAE.

FIG. 57. Labrum of Endromis versicolor.

BOMBYCIDAE.

FIG. 58. Labrum of Bombyx mori.

LASIOCAMPIDAE.

FIG. 59 and 60. Antenna, and front and labrum of Malacosoma disstria.

CERATOCAMPIDAE.

FIG. 61. Head of Basilona imperialis.
FIG. 62. Labrum of Anisota senatoria.
FIG. 63. Labrum of Citheronia regalis.

PLATE XV.

FIG. 64. Head of Anisota senatoria.
FIG. 65. Labrum of Basilona imperalis.

SATURNIIDAE.

FIG. 66. Head of Hyperchiria io.
FIG. 67. Maxillae and labrum of a half grown larva, supposed to be H. io.
FIG. 68. Maxillae and labium of adult larve of H. io.
FIG. 69. Labrum of Telea polyphemus. That of normal Tropaea luna is similar, but lacks the secondary hair.
FIG. 70. Maxillae and labium of T. polyphemus.
FIG. 71. Labrum of Tropaea luna. An aberration, apparently due to injury and imperfect regeneration. The form is changed, and setae *iii*, *iv* and *vi* are lost on the right side.
FIG. 72. Head of Tropaea luna. That of polyphemus is similar.

NOTODONTIDAE.

FIG. 73. Front and labrum of Datana integerrima.
FIG. 74. Front and labrum of Schizura concinna. That of S. badia is quite similar.
FIG. 75. Front and labrum of Cerura, penultimate stage.

PLATE XVI.

FIG. 76. Head of Melalopha.
FIG. 77. Ventral proleg of Cerura, extended.
FIG. 78. Anal leg of Datana ministra, penultimate stage, seen from the ventro-lateral point of view.
FIG. 79. Lateral view of stemapod, or anal proleg of Cerura, with the tip of the body.
FIG. 80. Nearly lateral view of anal proleg of Heterocampa guttivitta; about half of the row of crotchets is shown.
FIG. 81. Ventral proleg of the same, half retracted; extended it would resemble Figure 77 quite closely.
FIG. 82. Labrum of H. guttivitta. Nadata is quite similar.
FIG. 83. Labrum of Melalopha.

GEOMETRIDAE.

FIG. 84. Head of Lycia cognataria (?).
FIG. 85. Lateral view of sixth abdominal segment of the same, showing normal Ennomid position of the proleg, and seta *vib*.
FIG. 86. Labrum of the same.
FIG. 87. Ventral view of proleg of Zerene catenaria, opened on the outer side and flattened, to show the sucker, interrupting the row of hooks.

THYATIRIDAE.

FIG. 88. Heax of Cymatophora (Bombycia) or. Sketch to show form of epicrania.

DREPANIDAE

FIG. 89. Front view of head of Drepana arcuata.
FIG. 90. Seta plan of the same. The leg is indicated very diagrammatically.
FIG. 91. Labrum of the same.
FIG. 92. Lateral view of ventral proleg, showing the three true setae *vii*, the outer row of rudimentary hooks, and the two ends of the developed inner row.

PLATE XVII.

Lacosomidae.

Fig. 93. Ventral view of proleg of half-grown Lacosoma chiridota.
Fig. 94 and 95. Lower lip and head of L. chiridota.

Thaumetopoeidae.

Fig. 96 and 97. Labrum and claw of true leg of Thaumetopoea (Cnethocampa) pityocampa.

Lymantriidae.

Fig. 98. Front and labrum of Hemerocampa leucostigma.
Fig. 99. Labrum of Euproctis chrysorrhea.

Noctuidae.

Fig. 100. Head of Demas coryli.
Fig. 101. Tip of true leg of D. coryli. The moderately notched claw, and the three spatulate setae are typical, but not universal in the Macrolepidoptera.
Fig. 102 to 105. Labra of various species of Acronycta, to show variation within the genus.
Fig. 106. Labrum of Arsilonche henrici.
Fig. 107. Head of Hadena (Trachea) turbulenta.
Fig. 108. Head of Feltia sp.
Fig. 109. Part of head of Euxoa sp.
Fig. 110. Front of Cucullia sp.
Fig. 111. The ocelli of Nycteola revayana. (Right side).
Fig. 112. The ocelli of Earias chlorana.

PLATE XVIII.

Arctiidae.

Fig. 113. Head of Apantesis parthenice (?); the setae are somewhat shorter than in life, but not so much so as in most of the figures of heads in this paper.
Fig. 114. Head of Isia isabella.
Fig. 115. Mandible of the same, seen from the inner aspect.
Fig. 116. Mandible of Apantesis. (Of the opposite side).
Fig. 117. Front and labrum of Euchaetias egle.
Fig. 118. Lower lip of E. egle.
Fig. 119 and 120. Front and labrum more enlarged of Halesidota caryae.
Fig. 121. Labrum of Isia isabella.

Syntomidae.

Fig. 122. Labrum of Ctenucha virginica.

Megalopygidae.

Fig. 123. Lower lip of Lagoa crispata.
Fig. 124 Antenna of L. crispata (seen from the ventral side).

PLATE XIX.

Fig. 125. Labrum of Lagoa crispata.
Fig. 126. Half of the same, more enlarged.

Microlepidoptera.

Fig. 127. Front view of head of Psyche zelleri.
Fig. 128. Ventral view of proleg of Thyridopteryx ephemeraeformis.
Fig. 129. Sketch of lower lip of Cossus cossus, showing the general arrangement and proportions of parts.

FIG. 130. Tips of maxillae and labium of Cossus cossus; copied from Lyonnet. Twice the size of the original engraving. Only a small part of Lyonnet's figure is shown.
g. Subgalea.
d. f. Maxillae.
e. Mentum.
H. Maxillary palpus. The dotted line runs to the enlarged second joint characteristic of Cossus.
K. Labial palpi.
I. Sclerite *c.* at the base of the spinneret.
T. Large cones.

FIG. 131. Skin of Cossus cossus. Opened from the dorsal side, and with the larger muscles removed to show the retractor muscles of the proleg (2). The proleg itself is represented by an indistinct ring at the right end of the muscle. The midventral line runs just to the left of the muscle marked P. This is also a copy of a small part of one of Lyonnet's figures, enlarged about twice.

FIG. 132. Antenna of Melittia cucurbitae. (Sesiidae).

FIG. 133. Antenna of Cacoecia cerasivorana (Tortricidae).

PLATE XX.

VARIOUS FAMILIES.

FIG. 133. Partly lateral view of spinneret and neighboring parts of Thyridopteryx ephemeraeformis (Psychidae) to show an unusual amount of development of the sclerites.

FIG. 135. Ventral view of proleg of Lagoa crispata (Megalopygidae).

FIG. 136. Head of Argyresthia. (Tineina).

FIG. 137. Maxillae and labium of Cacoecia cerasivorana. (Tortricidae).

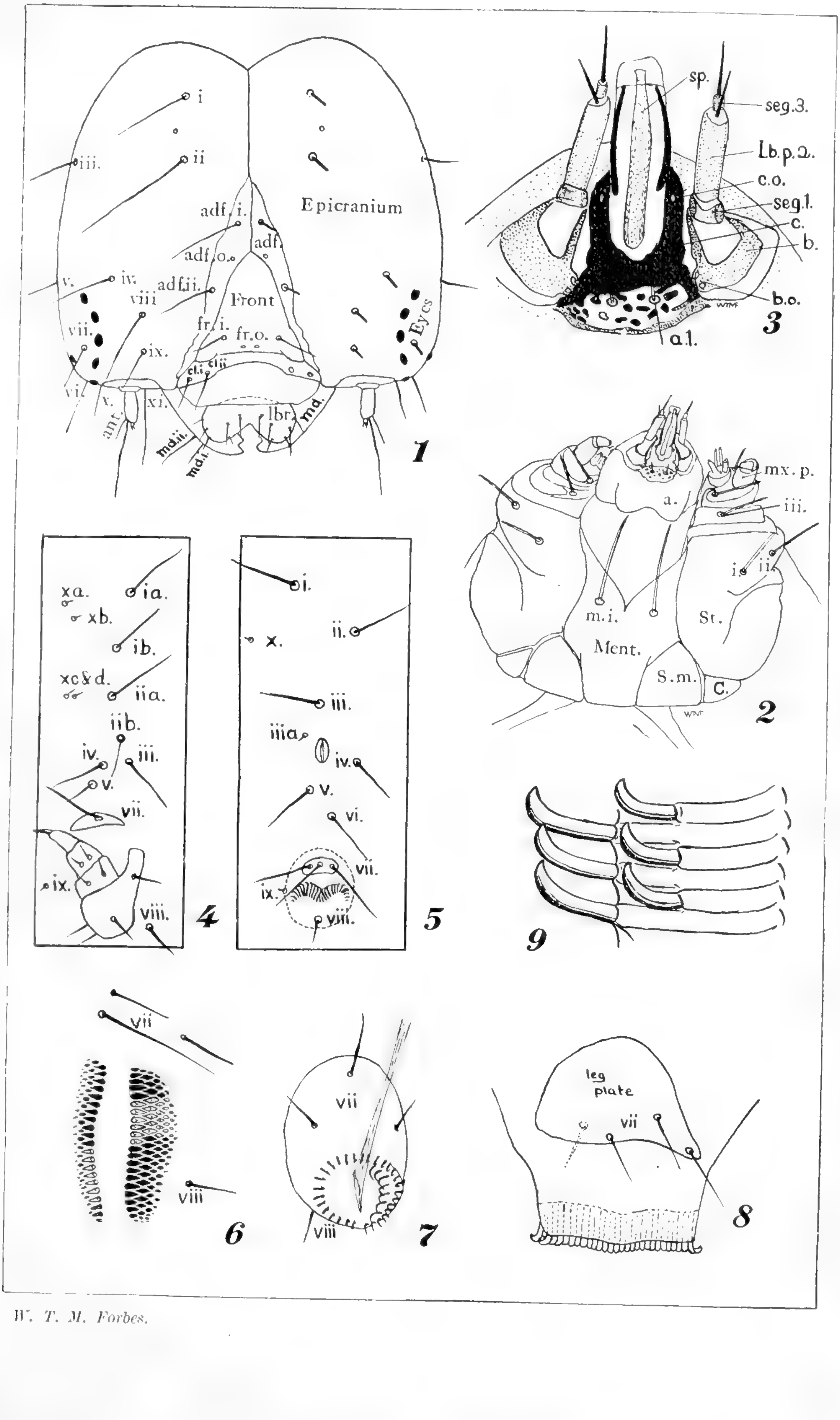
FIG. 138. Portion of skin of Rhodophora florida (Noctuidae) to show the type of granulation.

FIG. 139 and 140. Head and antenna more enlarged of Simaethis oxyacantha (Tineina).

FIG. 141. Antenna of Yponomeuta cagnagellus. (Tineina).

FIG. 142. Head of Depressaria putridella. (Tineina).

FIG. 143 Head of Endrosis lacteella. (Tineina).



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fr. i.
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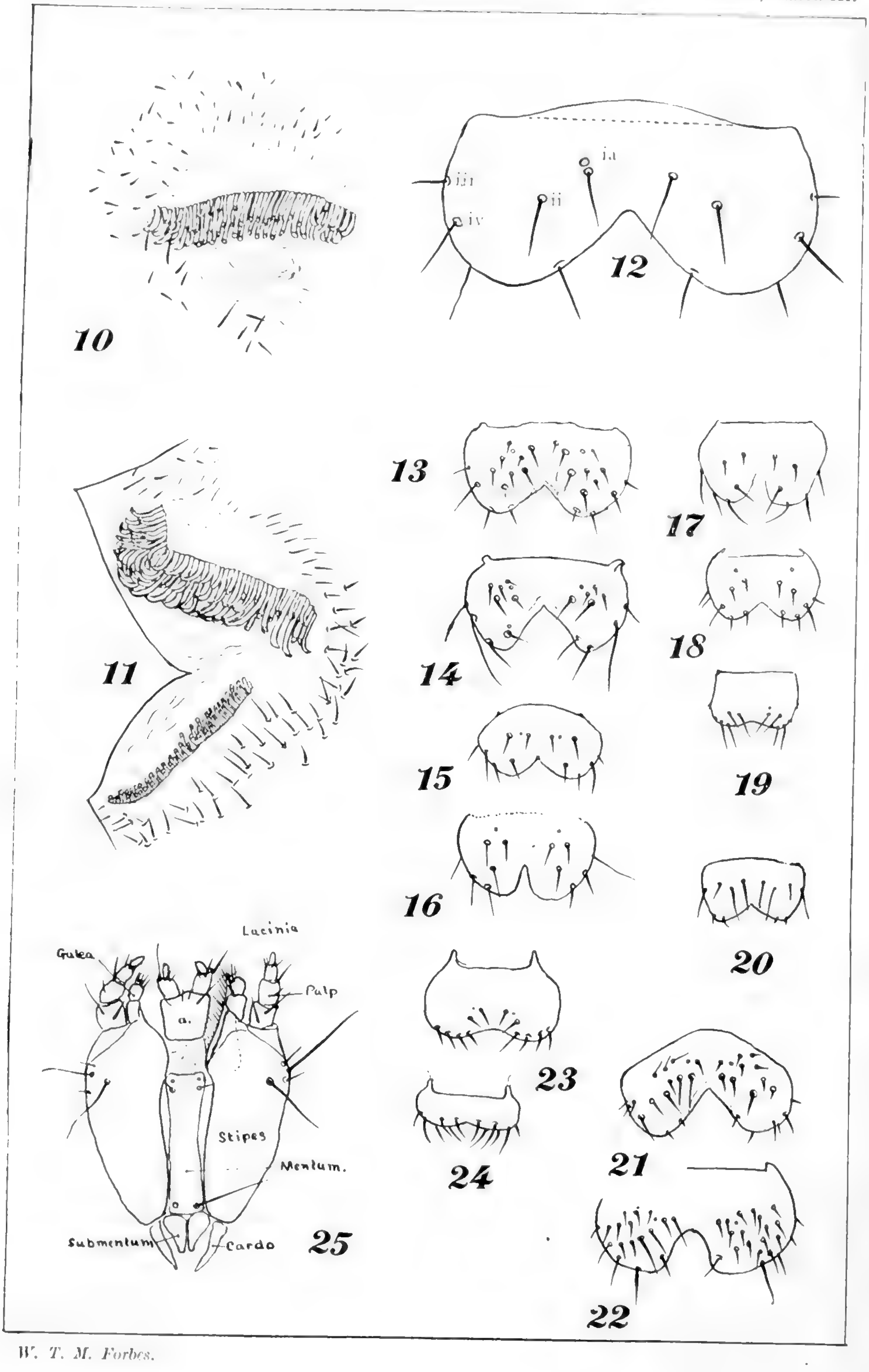
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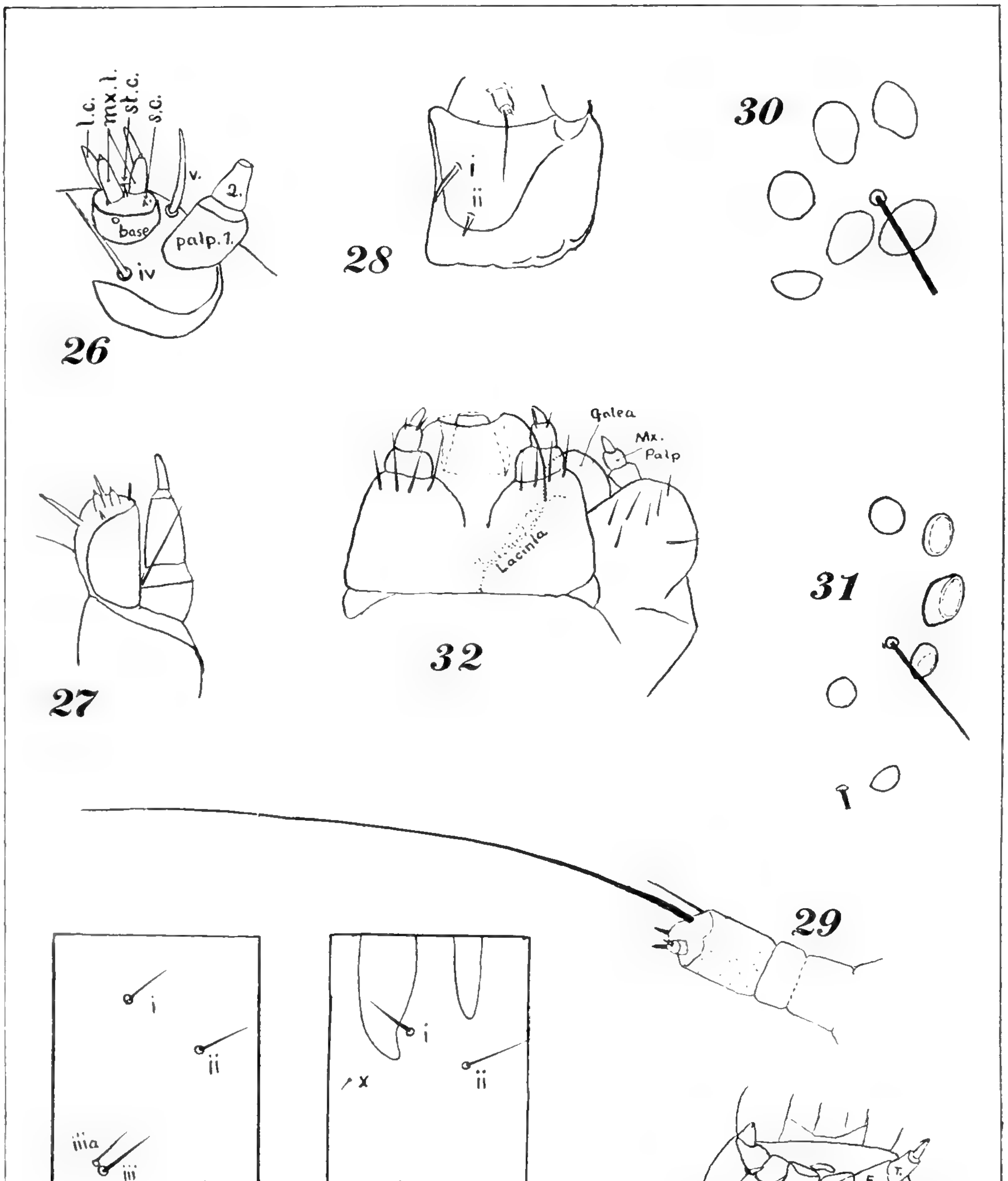
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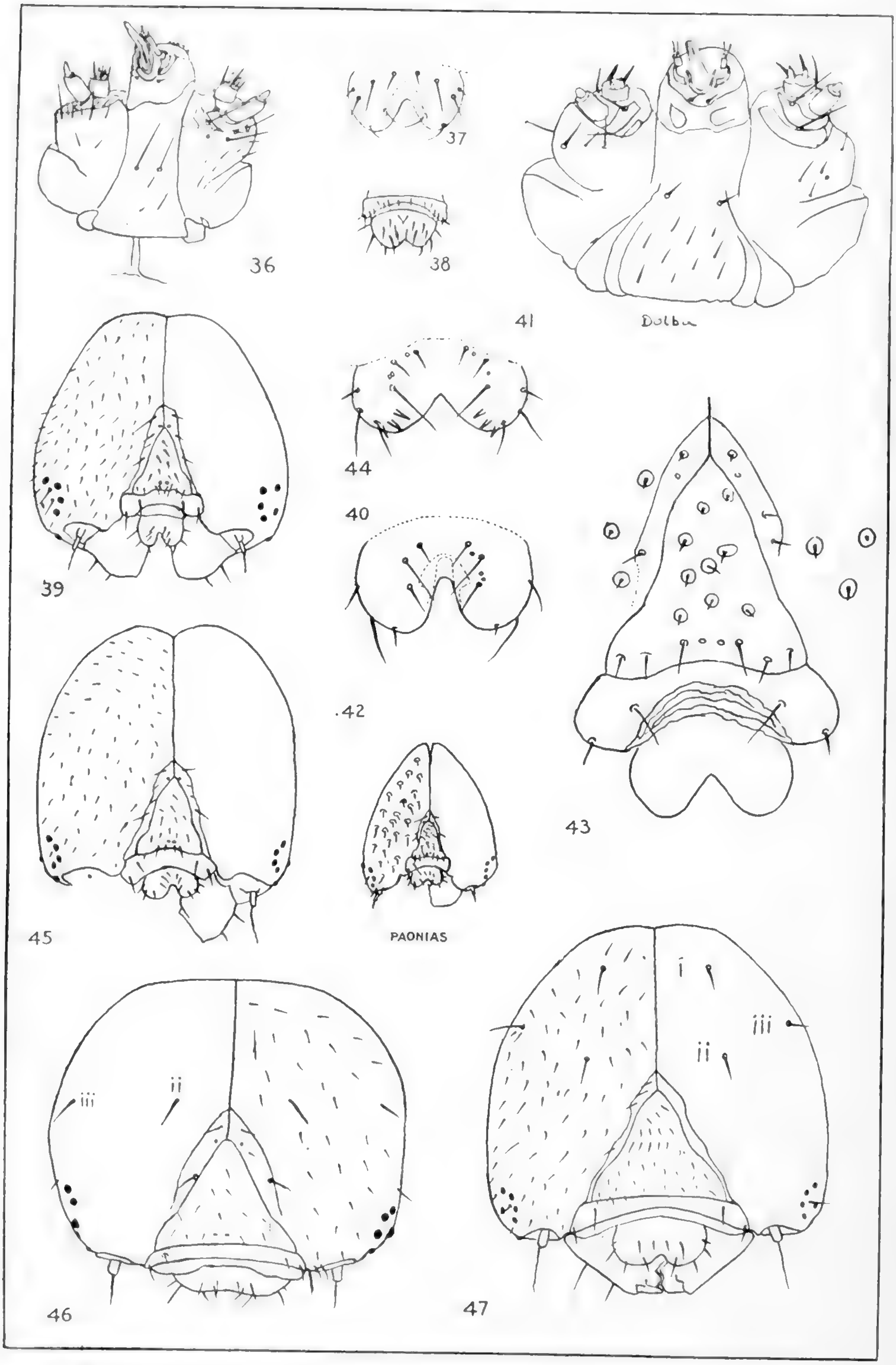

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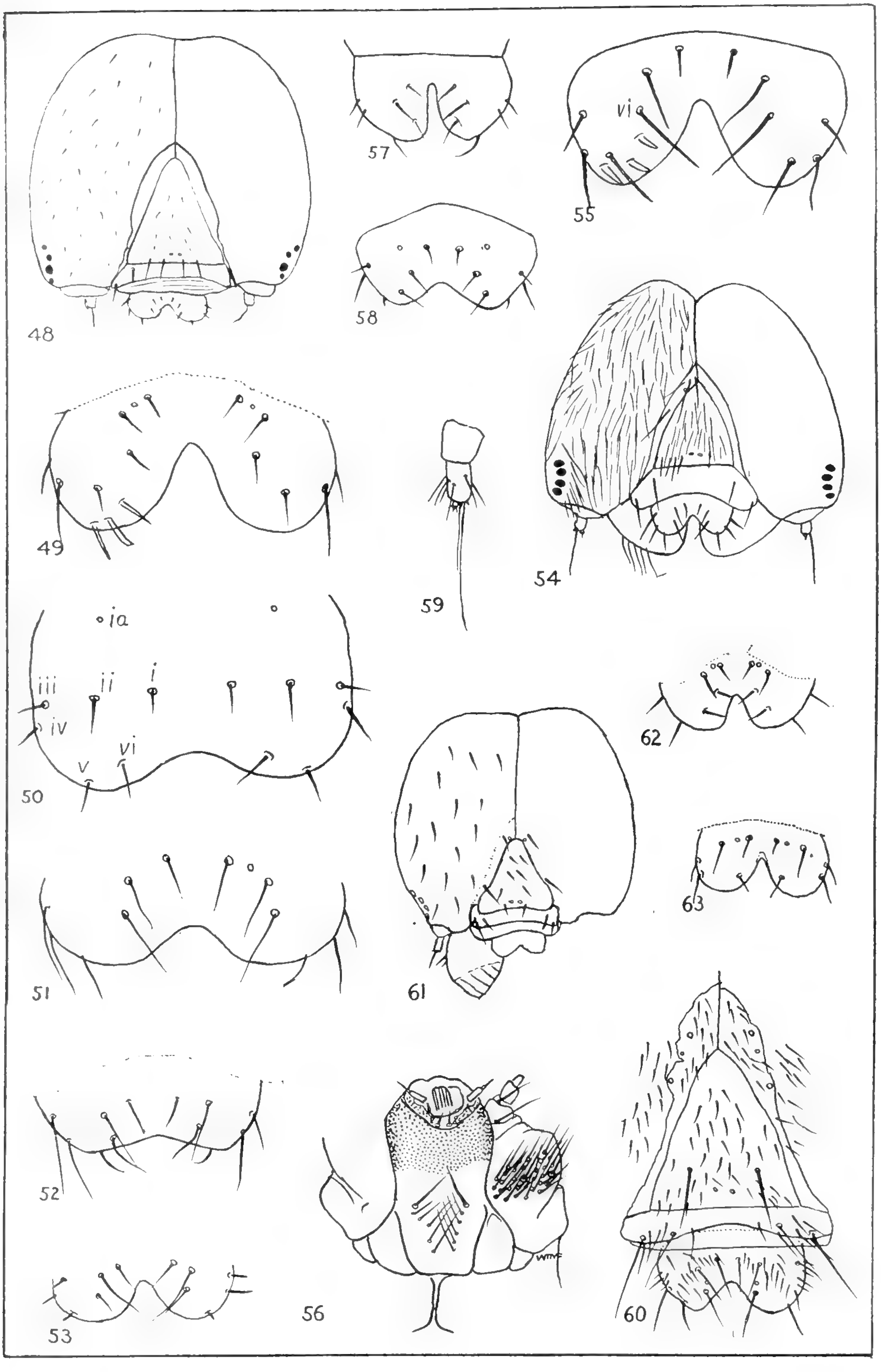

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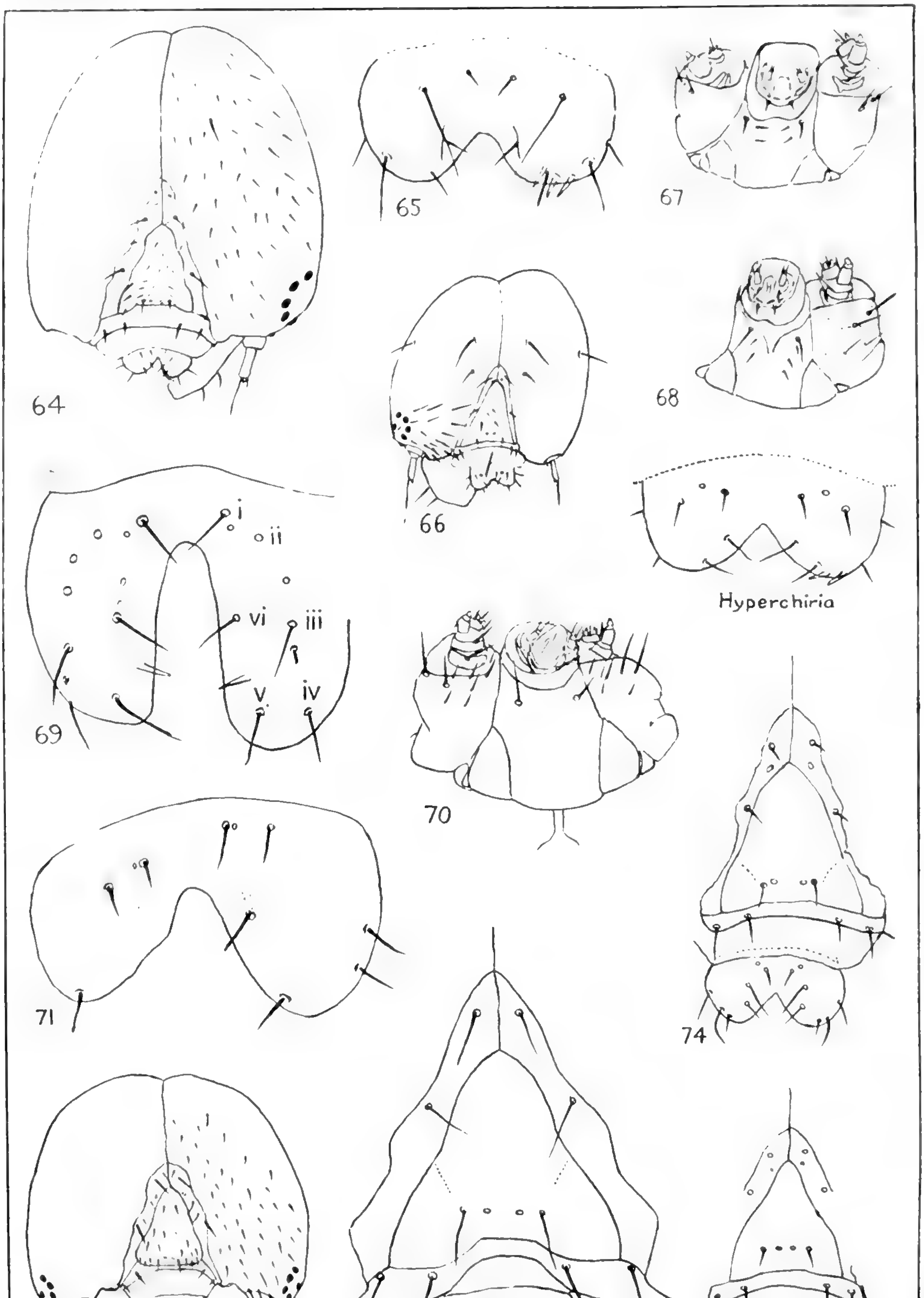

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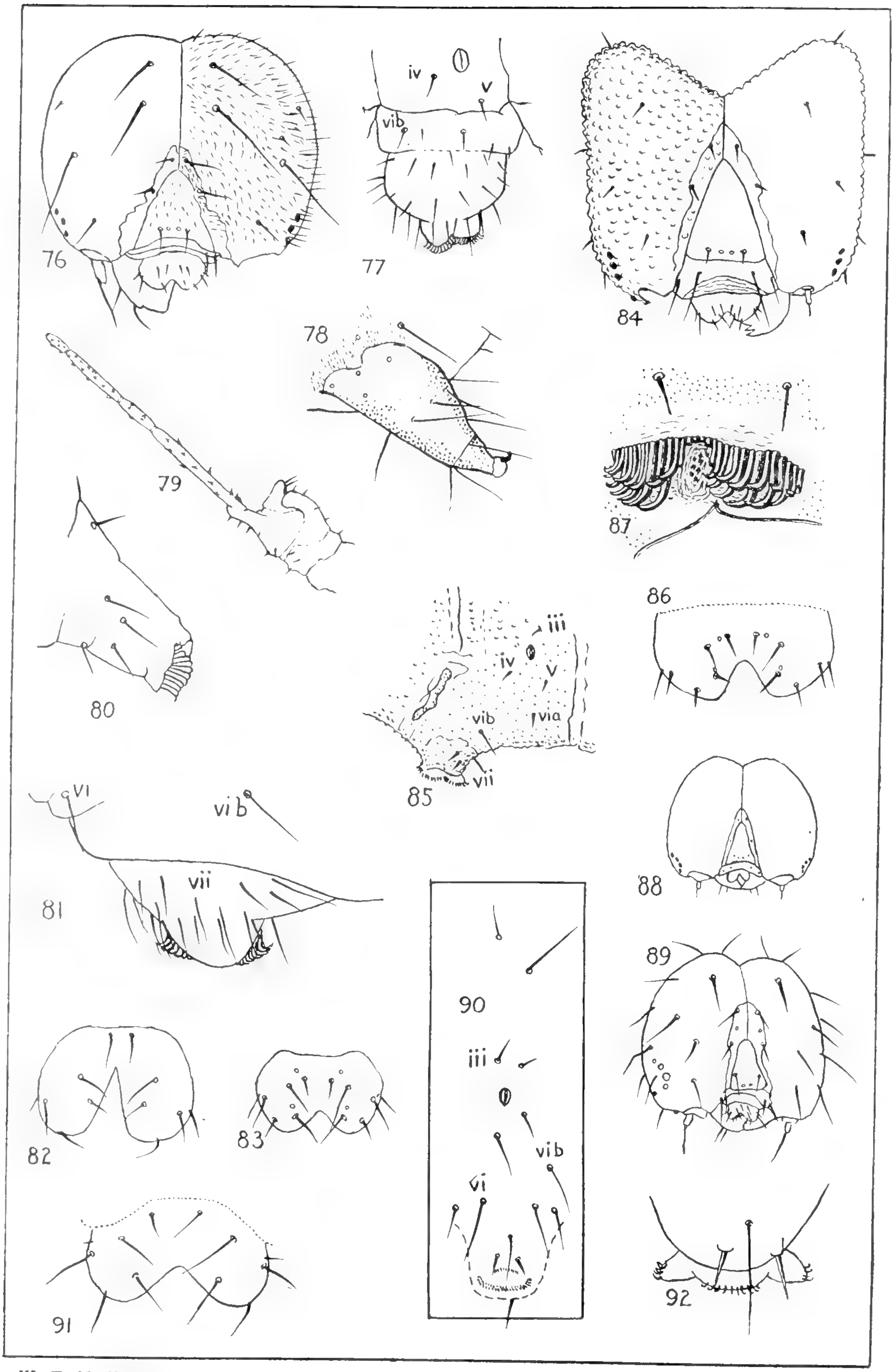
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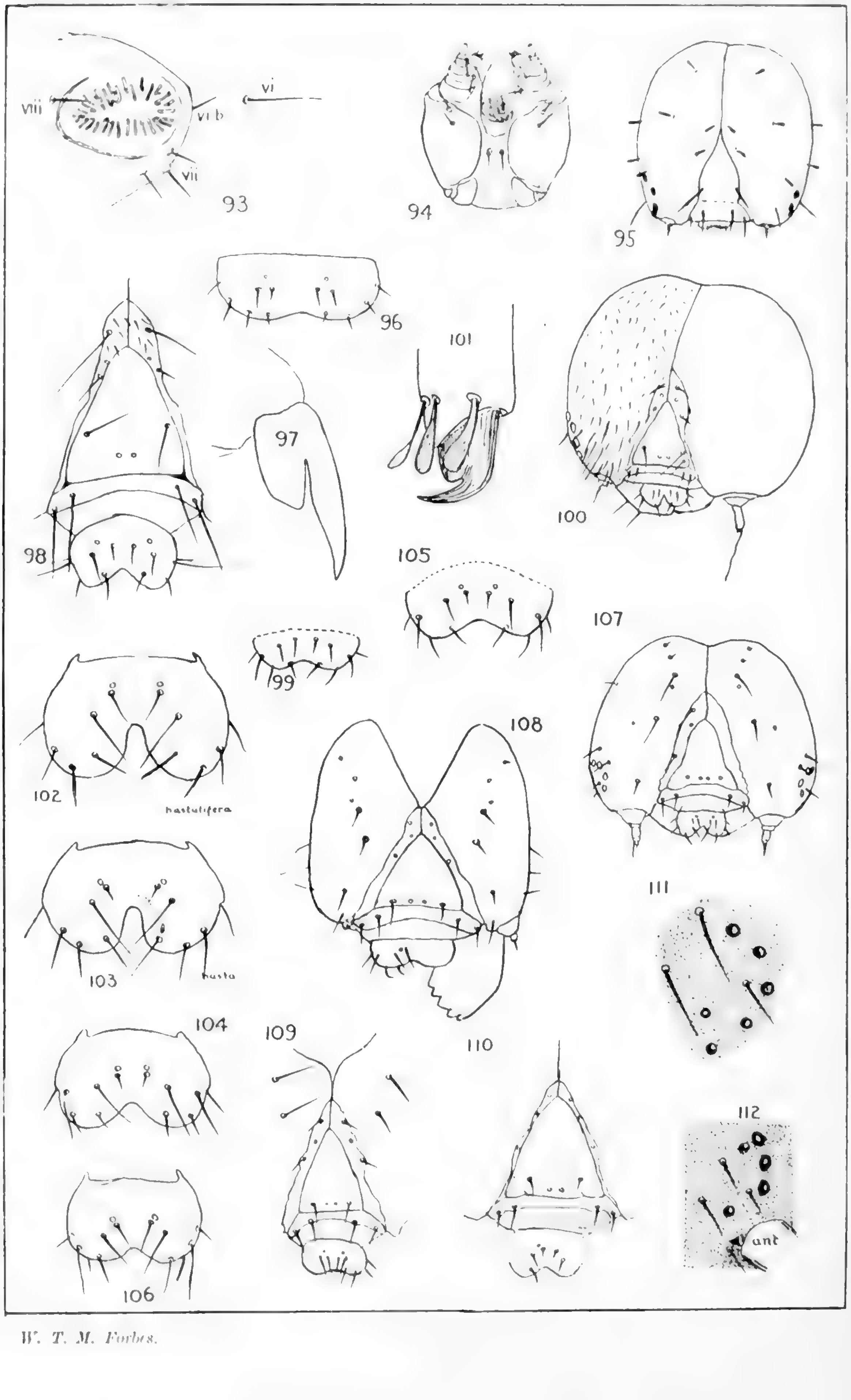
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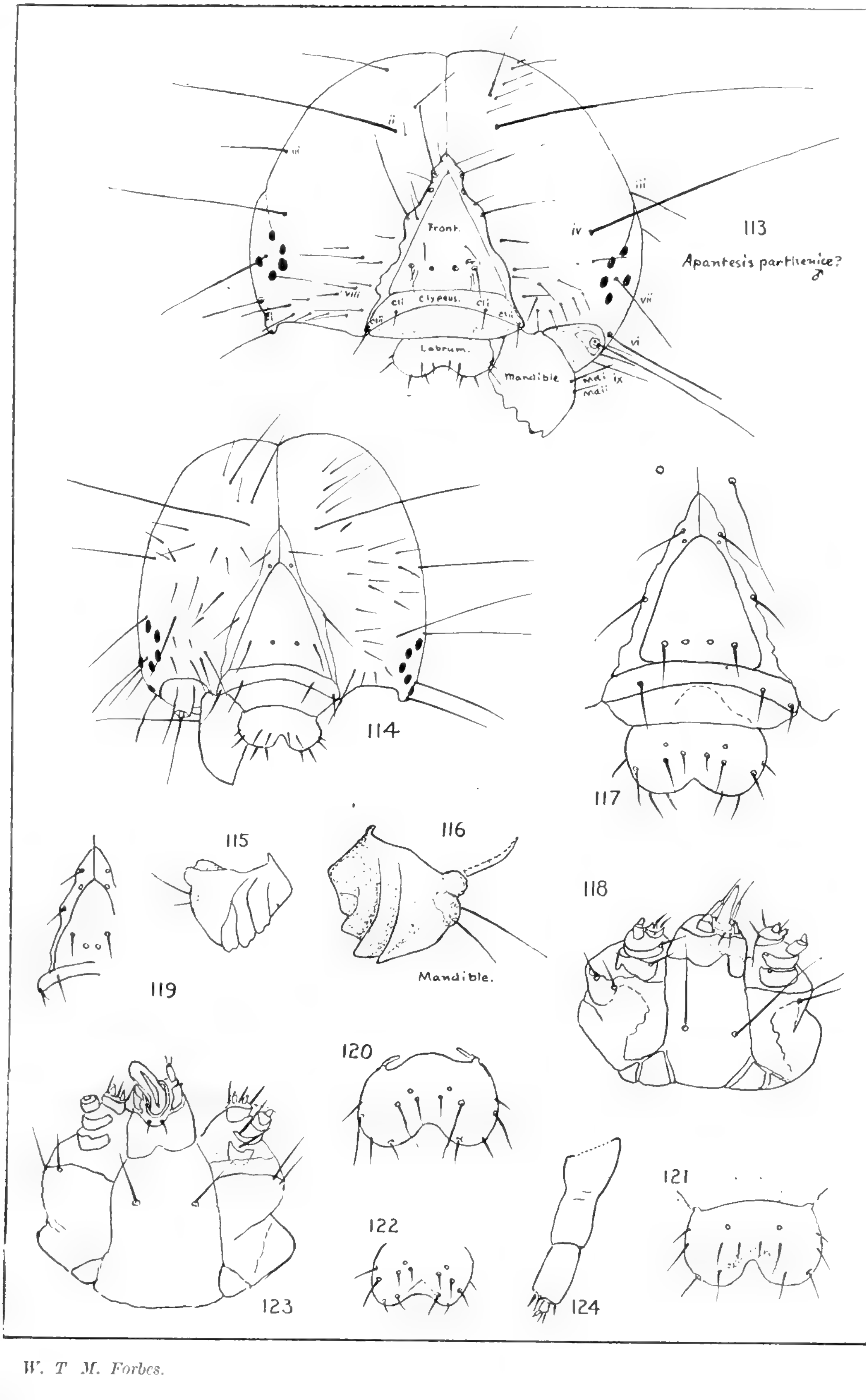
113
Apantesis parthenice? ♂
Front.
Clypeus.
Labrum.
Mandible
iv
vi
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Mandible.
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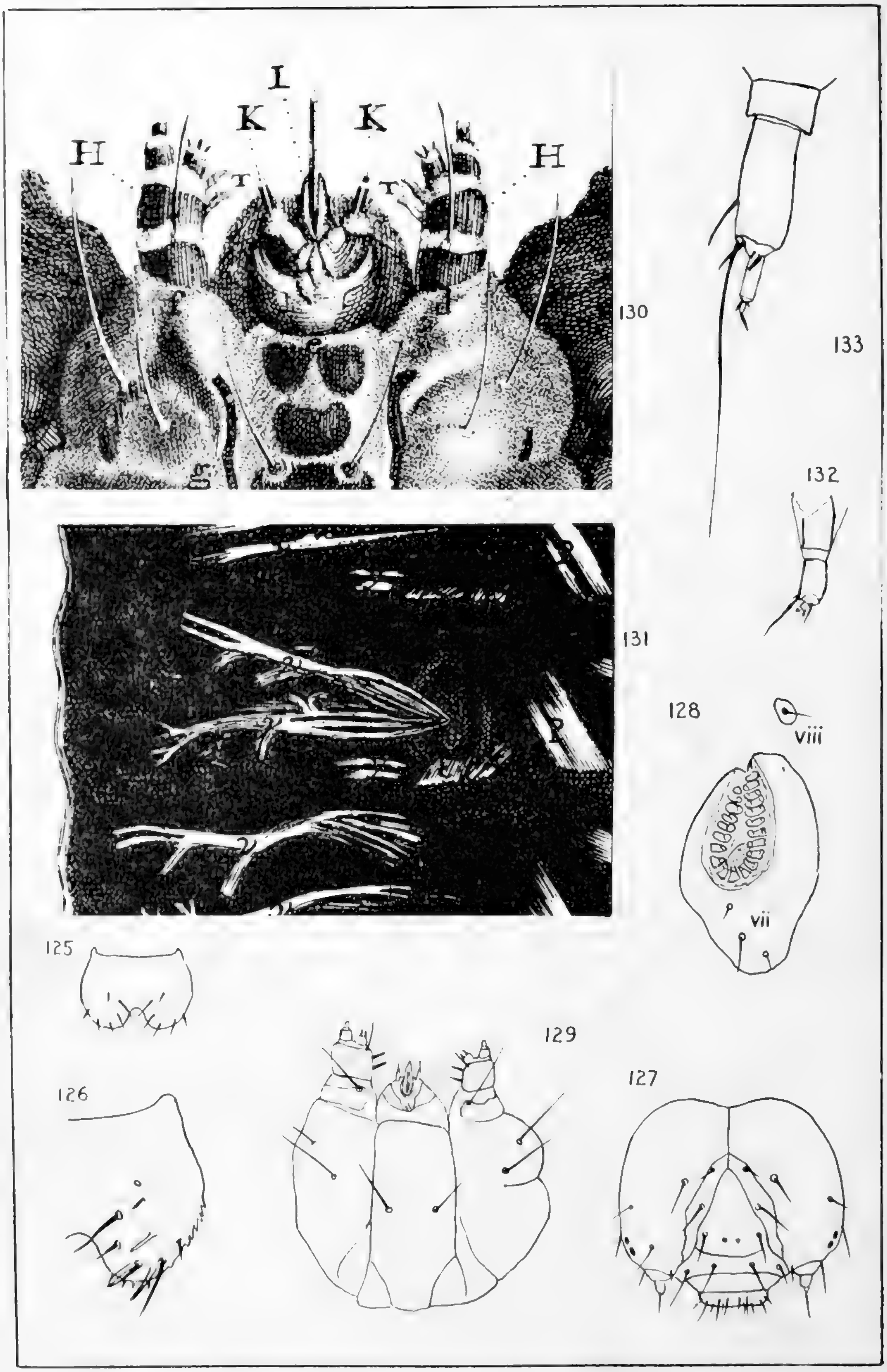

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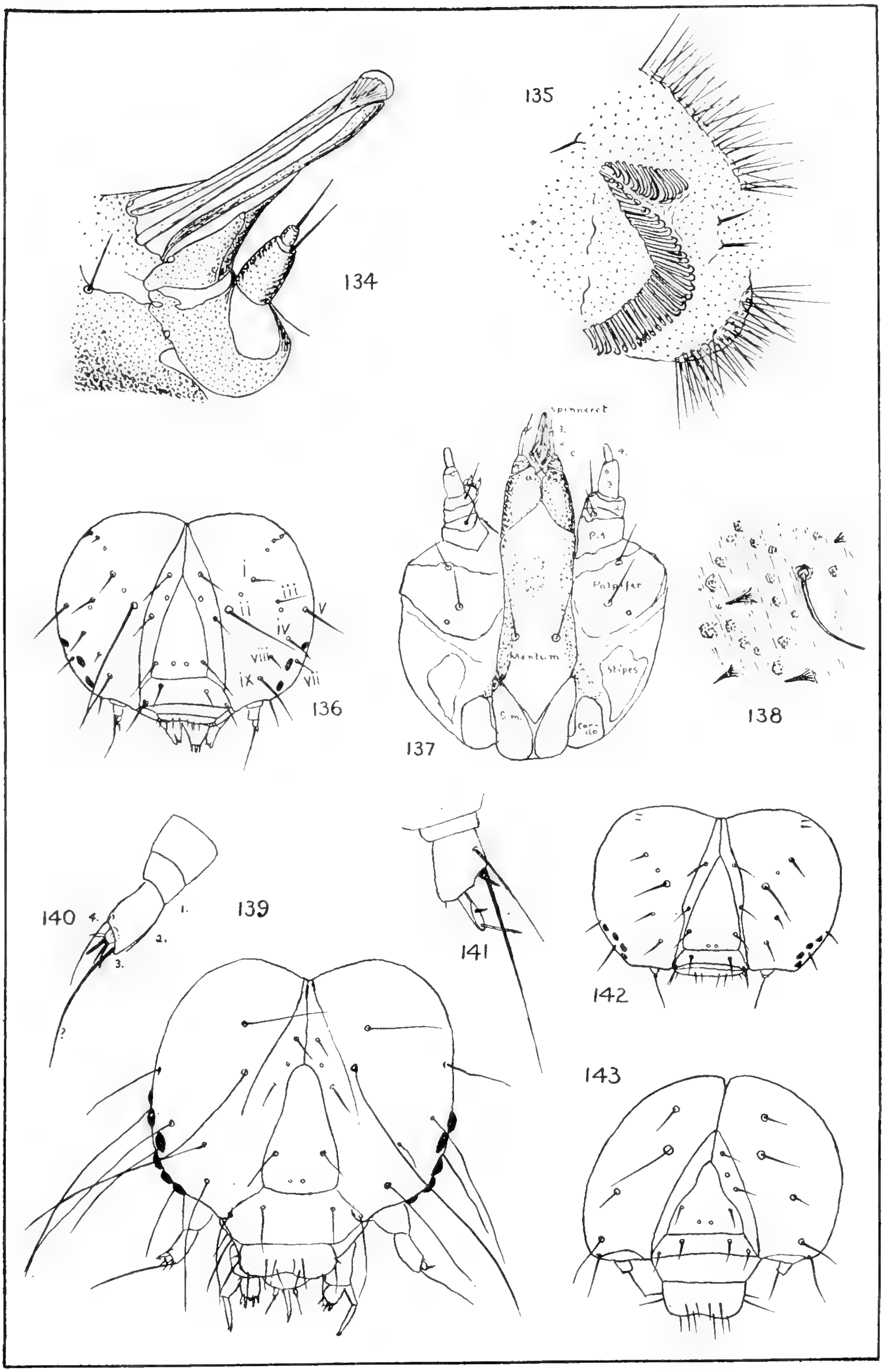
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THE LIFE CYCLE OF HORMAPHIS HAMAMELIDIS.

By T. H. Morgan and A. F. Shull.

Pergande* has described the life cycle of this species as consisting of seven generations, the first two and the sexual generations living on the witch hazel, and the other four on the black birch (Betula nigra), the latter four generations consisting of three aleurodiforms and one winged migrant.

Failure on our part to discover the aleurodiform generations in localities where the witch hazel was abundant, and the discovery that the winged migrants continued to emerge from the galls from the end of July until October, thus leaving no time for the intercalation of the four birch generations, led us to examine the life cycle of this species in the vicinity of New York.

Leaves of the witch hazel bearing galls of Hormaphis were enclosed in bags of paraffin paper about the first of August, when the migrants had begun to leave the gall. The bags were opened at intervals of about a week, and the under surface of the leaves examined. Nothing was found until about the first week in September, when the sexual forms were discovered on the leaves which had been in the bags. At the same time the sexual forms were also found on the leaves outside. The results show at least that the birch is not a necessary link in the life cycle of this species; and since no aleurodiform individuals were seen at any time on the witch hazel, their necessary occurrence in the life history seems, in this locality at least, to be excluded.

The final and conclusive evidence was obtained from a microscopic examination of the migrants within the witch hazel galls, and of the young stages, pupal and prepupal. Serial sections show that all these forms contain embryos that are males or females. The determination of the male embryos can be made owing to the fact that the testes early develop, and in the embryos in the winged stages of the migrant the characteristic spermatcoyte divisions can be found. In all of these, as in other aphids, a lagging chromosome is present, and two classes of sperm, functional and rudimentary, result. The determination of the sexual female can be made owing to the presence of a sypegesis stage in the eggs in the ovary.

* Pergande, Theo. "The Life History of Two Species of Plant-lice Inhabiting Both the Witch Hazel and Birch." U. S. Dept. of Agr., Div. of Entomology, Technical Series No. 9, 1901.

At Cold Spring Harbor, where these observations were made, three birches are present: Betula lenta is common, B. populifolia is uncommon, and B. lutea is rare. B. nigra is said to occur, but was not found. Winged migrants were placed on the leaves of the first three of these species in the evening; those on leaves of trees outside had left by 9 A. M. the next day; some of those on branches in the laboratory remained during the day, and were seen as late as 4 P. M., but had left by 8 A. M. on the following morning. They appear not to have deposited any young, since none appeared on the leaves during the following two weeks.

A branch of witch hazel with leaves bearing galls, and one of a birch (B. lenta), growing near together, were enclosed in the same bag. After about three weeks the bag was opened, when sexual individuals were found on the witch hazel leaves, but none on the birch.

The observations show that in the vicinity of New York, Hormaphis has a much simpler life history than that ascribed to this species by Pergande for the vicinity of Washington. It would seem to follow, either that further south there is a longer life cycle including an alternate host, or that Pergande has intercalated in the life cycle of this species several generations of some other (aleurodiform) species. Fortunately the question can be very simply decided by making a few serial sections of the winged migrants in the galls found in the District of Columbia.

Pergande's statement is so definite and detailed that it scarcely seems possible that he could be mistaken in regard to the life history of the Washington form. For example, he states on page 17, regarding the third generation: "Toward the middle or end of June the insects cast their third or final skin and assume a most remarkable mimicry; in fact, mimic now so closely certain Aleurodids that for some time I was completely deceived as to their true nature, which only after close examination of numerous specimens, in connection with its earlier stages, was disclosed. When seen on the leaves they are to all appearances true Aleurodids, both in shape and size, resembling to some extent the scale-like form of Aleurodes corni or related species." The fourth and fifth generations are also aleurodiform. "With the appearance of the sixth generation a new cycle of forms begins to make its appearance, in which the aspect of the insects has changed completely, so much so that the casual observer would fail to trace a connection between them and the Aleurodiform generations.

Continued observations, both in the woods and on small potted birches to which the insects were transferred, removed, however, all doubt as to the close relationship of these aberrant forms. This generation develops in time into the return migratory generation."

The return of the migrants to the witch hazel is described by Pergande as follows (p. 21): "Having cast their fourth or final skin, they acquire wings and, after feeding for some time to complete maturity, forsake the birch and migrate back to witch hazel to deliver themselves of the ultimate or sexual generation. Each migrant, according to size, contains from seven to fifteen or perhaps more larvae. Migration continues for about a month and a half, according to conditions of the season and other natural causes, and commences usually toward the end of August and terminates during the early part of October. In general appearance they are essentially the same as those of the spring migrant from the witch hazel, though they are uniformly smaller * * * ." From these statements it appears that Pergande has observed not only all the intermediate stages between the young of the spring migrants from the witch hazel and the aleurodiform generations on the birch, but also the development of the return migrant from the aleurodiform individuals on small potted birches in confinement.

AN APPARATUS FOR THE DETERMINATION OF OPTIMUMS OF TEMPERATURE AND MOISTURE.

By Thomas J. Headlee,
Manhattan, Kansas.

Pioneer work in economic entomology consisted in the determination of the insect's life history and habits without more than casual regard to the environment in which it lived. From time to time, however, various workers have called attention to the fatal effects of the extremes of temperature and moisture, and a few persons have pursued systematic inquiry into the relations existing between temperature and insect life. Others have used various arthropods in determining the response of protoplasm to various stimuli. The last two types of investigation have proceeded far enough to show that insects in common with other organisms have minimum, optimum and maximum relations to each important stimulus to which they are subjected. More than enough work has been done to show that the life economy of the insect depends to a very large extent directly and indirectly upon the physical, chemical, and animate environment in which it lives, and that no fundamental understanding of its life economy can be reached until the effect of its environment is understood.

While the study necessary to the accumulation of sufficient data to arrive at such an understanding is one requiring much time and expense, certain insects are of such transcendent economic importance that the expenditure of enough time and money to make the most exhaustive study is entirely justifiable. Such insects have as a rule already received pioneer study and a few, owing to their especially marked response to environmental factors, have received more fundamental attention. The writer was first led to see the necessity for making a more fundamental study of highly injurious species by the observation that for certain of the insects most injurious to staple crop production—insects that exact a yearly toll of millions from the state in which he is now located—only inadequate measures of control have been devised, although they have been subjects of study for many years.

In making a study of the relation of environmental factors to the life economy of insects, either the investigator must deal with a sufficiently large number of individuals and instances to

FIG. 1

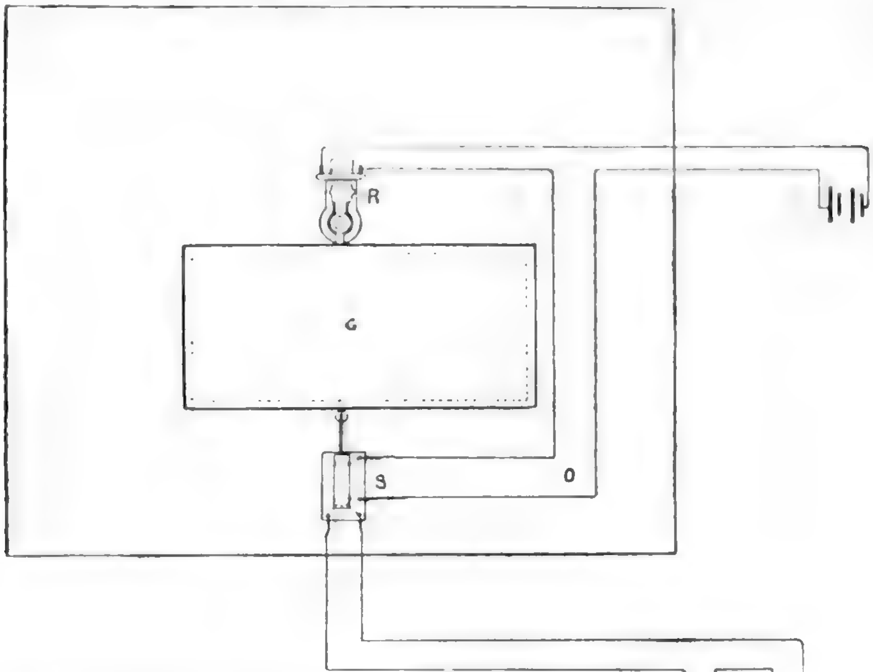
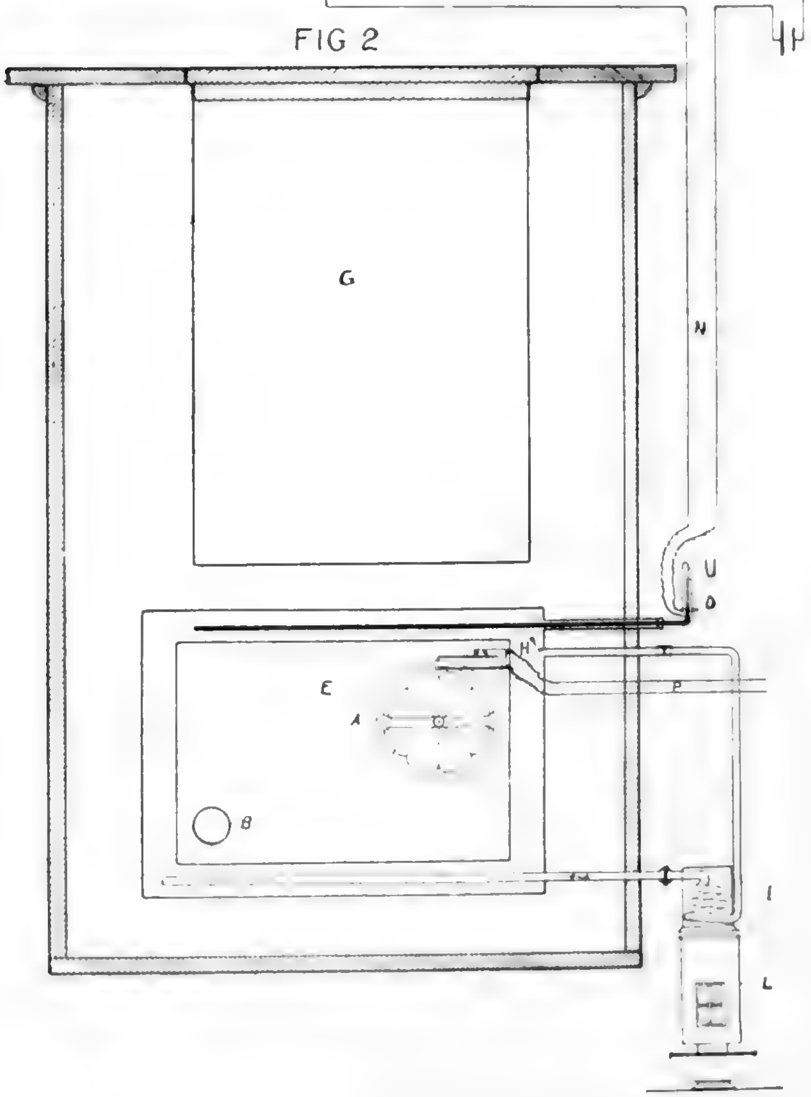


FIG 2



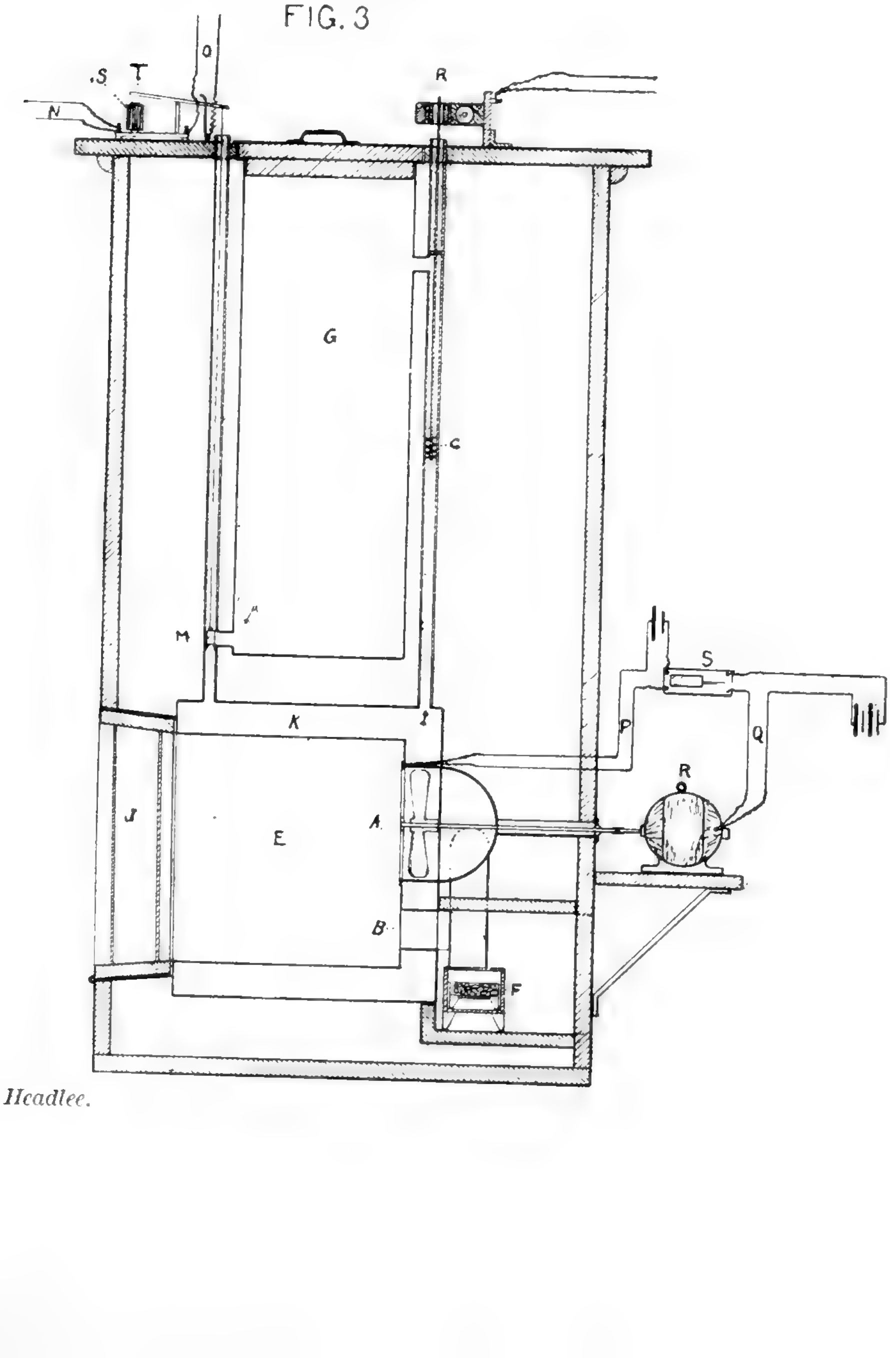
T. J. Headlee.

DIAGRAMATIC VIEW OF CONSTANT TEMPERATURE AND MOISTURE INCUBATOR.

FIG.1 = TOP VIEW
FIG.2 = FRONT VIEW
FIG.3 = SIDE VIEW

A = EXHAUST FAN AND PASSAGE WAY TO LEAD BOX
B = PASSAGE FROM LEAD BOX
C = SPIRAL LIFT
D = THERMOSTAT
E = EXPERIMENT CHAMBER
F = LEAD BOX CONTAINING CALCIUM CHLORIDE
G = ICE CHAMBER
H = HYGROSTAT
I = HEATING COIL
J = GLASS FRONT OF CHAMBER
K = WATER JACKET
L = KEROSENE HEATER
M = VALVE
N = TEMPERATURE-MAGNETIC CIRCUIT
O = " -MOTOR "
P = MOISTURE-MAGNETIC "
Q = " -MOTOR "
R = MOTORS
S = ELECTRO-MAGNETS
T = LEVER U = ELECTRODE

FIG. 3



T. J. Headlee.

reduce the error of the average to a negligible quantity, or he must deal with smaller numbers under conditions in which the important variables are reduced to constants.

In planning a study of the life economy of certain insects most injurious to staple crop production, the writer has adopted the plan of using the smaller number of individuals and of reducing the number of variables to a minimum. Of course it has been easy to eliminate natural enemies and to prevent large variation in the quantity and quality of food supply, but of the physical factors he has thus far been able to reduce only temperature and moisture to constants. This has been accomplished through the construction of an incubator, in which, within limits, desired degrees of each can be maintained.

Construction of the Apparatus. Plates XXI–XXII.

Temperature Phase.

Essentially the incubator consists of a water-jacketed chamber E (figs. 2 and 3) with special provision for heating and cooling the water within the jacket, the whole being surrounded by a box filled with non-conducting packing. The packing used in this instance consisted of wood shavings. The 12″ x 12″ x 18″ chamber is jacketed on three sides only, the fourth being closed by a double glass door for the purpose of admitting light. The water is cooled by the inflow of ice water from tank G (Fig. 3). This exchange is automatically controlled by means of mercurial thermostat D (fig. 2), which projects far into the jacket.

The platinum-tipped electrode U (fig. 2) has been so adjusted that when the temperature of the water within the jacket rises higher than is necessary to bring the air in chamber E (fig. 3) to the desired point, the rising mercury column in D (fig. 2) makes contact with it and completes magnetic circuit N (figs. 2 and 3), magnetizing electromagnet S (fig. 3), pulling lever T (fig. 3) down upon it, thus pulling valve M out of its seat and allowing ice water to flow by gravity into the jacket. The pulling of the lever down on the electromagnet S (fig. 3) completes motor circuit O (figs. 1 and 3), and sets spiral lift C (fig. 3) in motion. This interchange impelled by gravity is thus hastened by pumping. This interchange continues until enough cold water has been introduced into the jacket to cause the mercury column in D (fig. 2) to withdraw from the electrode U (fig. 2). So soon as this happens valve M (fig. 3) falls back into its seat and spiral lift C (fig. 3) stops.

The water within the jacket is heated in coil I (fig. 2) by means of kerosene burner L (fig. 2). The method of heating could be greatly improved where constant electric current is available by the installation of electric heaters under chamber E (fig. 3) and the controlling of the amount of current delivered by some form of thermostat. This portion of the incubator was devised and constructed by the "International Instrument Company," and later so modified by the writer as to fit it for his use.

Moisture Phase.

While certain companies would undertake the construction of constant low temperature incubators, we were unable to obtain a combination constant low temperature and moisture incubator. On the arrival of the constant low temperature incubator, we set about devising a means of bringing the relative humidity under control. After trying many things the writer adopted the method of placing enough plants or water vessels in chamber E (fig. 3) to bring the relative humidity to 100°, then when the relative humidity reached the desired point to prevent its further rise by passing the air over calcium chloride.

An exhaust fan A (figs. 2 and 3) was placed in the rear wall of the chamber E and the air led through a $2\frac{1}{2}''$ passageway into a leaden box F (fig. 3) partly filled with calcium chloride, and from there through a similar passageway B (figs. 2 and 3) back into the chamber. The fan, passageways, and leaden box are all included in the packing space of the incubator wall. A strand of human hair, after having the oil removed from it with sulphuric ether, was stretched in an adjustable brass frame. A lever was attached by its short arm to this hair in such a way that variation in the length of the hair strand would cause the distal end of the long arm to move through a considerable space. To this end of this arm was attached a platinum electrode which descended into a mercury-filled tube. Of course, the contact of the platinum point and the mercury was designed to close magnetic circuit P (figs. 2 and 3) and this to close motor circuit Q (fig. 3) which would set the exhaust fan in motion. So long as the platinum point remains in the mercury, the fan continues to change the air. Less than a minute after the connection is made is usually sufficient to dry the air to a point at which the contraction of the hair breaks the connection.

Operation.

In operating the incubator, it is necessary to set the automatic apparatus for both temperature and moisture. The former is accomplished by introducing a standard thermometer into chamber E (fig. 3) and when the rising temperature reaches the desired point, adjusting the electrode so that it almost touches the rising mercury column in D (fig. 2). The latter is accomplished by introducing a standardized hygrograph into chamber E. (Fig. 3) and when the rising relative humidity reaches the desired point, setting the tension of the hair strand so that any further loosening and lengthening will allow the platinum point to make contact with the mercury.

So long, then, as the heat maintains a constantly rising temperature and the ice in the tank is replenished, constant temperature will be maintained in chamber E (fig. 3) and so long as a constantly rising relative humidity is maintained in chamber E (fig. 3), and the calcium chloride is replenished, the constant relative humidity will be maintained.

Its Use Illustrated.*

Inasmuch as the data derived from use of the incubator in the study of *Toxoptera graminum* Rondani are most available, they will be used for illustration.

The determination of the optimum temperature was first attempted. The incubators were so placed that they would get the same quantity and quality of light. The moisture apparatus was set at 75° relative humidity and the temperature apparatus at different temperatures. A considerable number of individual viviparous *Toxoptera graminum* were allowed to complete their life cycles. The temperature was then changed and the experiment repeated. This process was continued until the effect of temperatures of 50° F., 70° F., 80° F., and 90° F., under constant relative humidity of 75° had been tested.

It is generally accepted that the optimum temperature of an organism is that temperature under which the organism's vital processes are most active.

The temperature under which these insects experienced the lowest mortality and produced the largest number of healthy young in a given time has been considered the optimum tempera-

*The writer desires hereby to acknowledge the aid afforded him by his student assistant, Mr. Francis B. Milliken, who under his immediate direction has tested different plans for the control of moisture and collected data from the insects under observation while the incubators were in operation.

ture. Chart No. 1, curve No. 4 shows that in our tests *Toxoptera graminum* experiences the lowest mortality at 80° F., curve No. 3 shows that the highest daily reproduction is at 80° F., curve No. 1 shows that the shortest time from birth to maturity occurs at 80° F., and curve No. 2 shows that the average period of reproduction is only a little less at 80° F., than at 70° F.

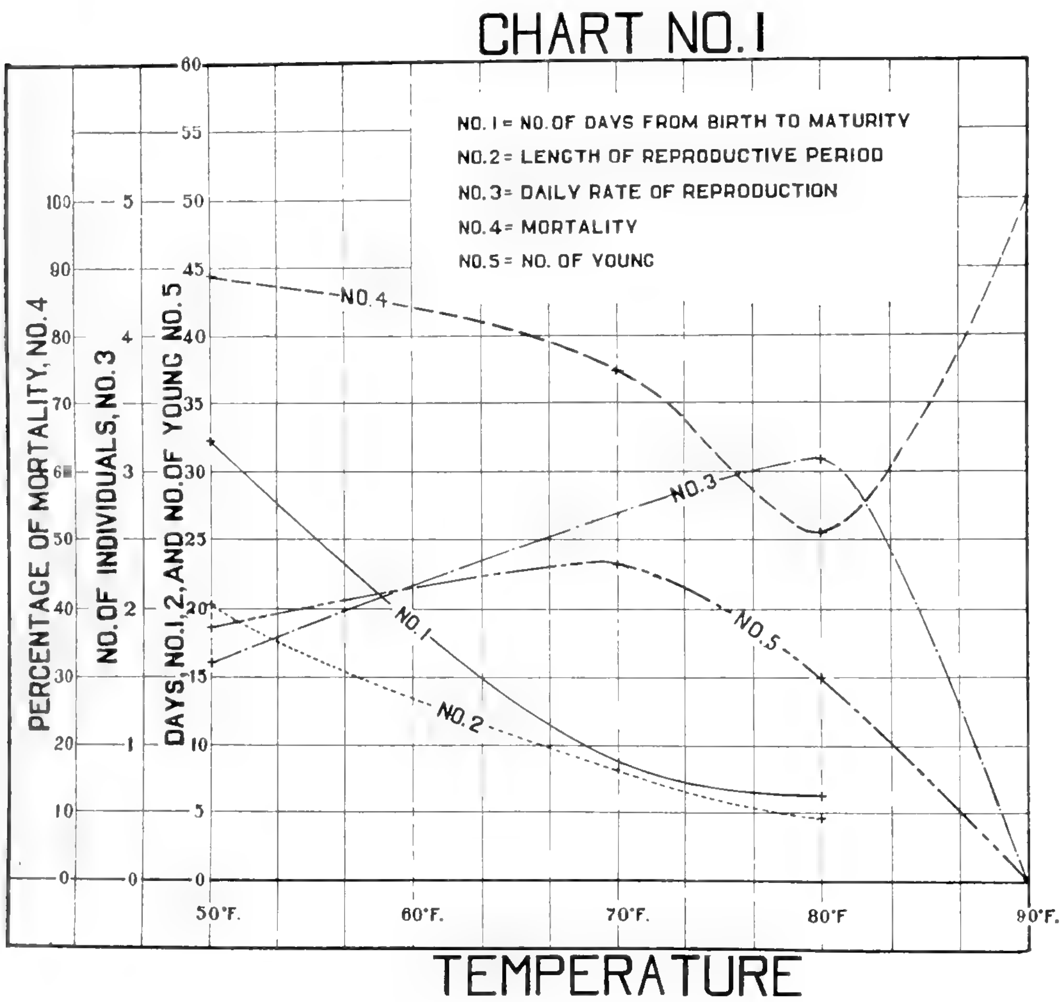


CHART No. 1.—Plotted data showing the relation of *Toxoptera graminum* Rondani to temperature under constant relative humidity of 75°. In curves No. 1 and No. 2, point at 50° F. represent the average of 6 individuals, at 70° F. 27, and at 80° F. 28. In curves No. 3 and No. 5 point at 50° F. represents the average of 6 individuals, at 70° F. 27, at 80° F. 28, and at 90° F. 201. In curve No. 4 point at 50° F. represents the average of 54 individuals, at 70° F. 108, at 80° F. 57, and at 90° F. 201.

Clearly, taking into consideration the effect of higher daily rate and shorter period of immaturity on the geometric rate of increase, *T. graminum* will under constant relative humidity of 75° produce the maximum number of progeny in a given time at 80° F. It is, therefore, reasonable to conclude that the optimum temperature for *T. graminum* under 75° relative humidity is about 80° F., possibly a little above or a little below.

NOTES ON CERTAIN SPECIES OF MAMESTRA.

By John B. Smith, Sc. D.

In 1852, Guenée described *Hecatera laudabilis* in Vol. II, p. 30 of his Noctuelites, and figured it very recognizably on Pl. VIII, figure 4. The locality given was "Amerique septentrionale," Coll. Doubleday, and the larva was described from a figure of Abbot. The type is now in the British Museum.

In 1856, Walker described *Hapalia indicans* in Vol. X, p. 359 of the British Museum Catalogue, and records two specimens, ♂ and ♀ from E. Florida, presented by Doubleday. In 1857, in Vol. XI, p. 511, of the same publication, Walker refers to *Hecatera laudabilis* Gn., gives a brief latin diagnosis and records 4 examples: 2 from East Florida out of the Doubleday collection, and 2 without locality out of the Milne Collection. He apparently had no idea that this was the same species that he had described in a previous volume.

In 1868, Grote and Robinson referred *indicans* as a synonym of *laudabilis*, in the Trans. Am. Ent. Soc. II, p. 78, after examining the types, and that reference was accepted by me and more recently by Hampson.

In 1860, Wallengren described *Hecatera strigicollis* in the Wien. Ent. Monatschr., IV, 170, and gave the locality as California. That species remained unidentified in our lists until 1891 when, in my revision of *Mamestra*, I re-published the description without, at that time, suggesting its identity with any other described species. In 1893, after seeing the British Museum collections, I referred the species, in my Catalogue of Noctuidæ to *laudabilis*, and in this reference Hampson has also followed me.

In 1875, Grote described *Mamestra illaudabilis* in Vol. VII, p. 27, of the Canadian Entomologist, differentiating it very briefly from *laudabilis*. It is recorded from California and from Vancouver Island, out of the Henry Edwards Collection, and both sexes were present. In 1881, Mr. Grote lists *illaudabilis* as a variety of *laudabilis*, and again points out certain color differences between the eastern and western specimens: differences which, unfortunately, are not constant nor, as the distribution given proves, very useful in separating the species. In my revision of 1891, I accepted Mr. Grote's ranking of the species, but was in error as to the form to which the name *illaudabilis* should be applied. In my figure of the genitalia I obviously got hold of

an imperfect or broken structure and, while it is reasonably accurate so far as it goes, it is altogether misleading as representing the real structure of the *illaudabilis* form which, obviously, I used for the dissection. In 1905, Hampson, having before him the types of Guenée, Walker and Grote, lists all names under *laudabilis*, but as "Ab. 2, *illaudabilis*," he designates those forms in which the green tinge is almost entirely replaced by white.

During the two or three years last past it has been my fortune to handle very large series of these forms from all parts of the country, and the more of them I handled, the less satisfied I became with the association. Recently, in re-arranging the species in this series, I gathered in all my material for comparison, and demonstrated to my own satisfaction two very good species; the one extending throughout the eastern and southern States and into Texas, the other through the Rocky Mountain region into Arizona and west to the Pacific Coast. The true *laudabilis* is a chunky, heavily built species with comparatively short, broad, obtuse primaries. *Strigicollis*, which must be used for the other species, is slighter throughout, the primaries narrower, more trigonate, with apices more obvious. In color, *laudabilis* when fresh, is always greenish, fading out to whitish, with the median space ranging all the way from reddish to black, often greenish below the sub-median vein. The space also tends strongly to narrow inferiorly. In both sexes the secondaries may range from blackish to almost pure white, and the general impression is that of a stout, heavily built insect. *Strigicollis*, on the other hand, never has that delicate green tinge in even the freshest examples, and many of them are almost clear white. In others there is a mossy olivaceous tinge which often darkens the normally pale portions of the wing. I have never seen a specimen with a reddish median area, but this may range anywhere from olivaceous brown to black. The median space while it tends to narrow inferiorly, never approximates the median lines so closely, and does not often tend to give a wedge-like impression. The secondaries are more uniformly pale in both sexes, and the impression, as already stated is of a slighter species than *laudabilis*.

Finally, as there was plenty of material available, I tested the male genitalic structures once more, and demonstrated the distinctness of the two series beyond peradventure. A comparison of figure 1 with figures 2, 3 and 4, will show that it is not a matter of slight differences, but of quite a radical change. In *laudabilis*,

of which specimens from New York to Texas were examined, there was not enough variation to warrant more than a single figure. The harpes are very broad at base, with a very narrow rather short extension, and a small extension at tip. There are two distinct claspers and one of them is spatulate. The corneous sheath of the penis is very long in all the examples.

Seven examples of *strigicollis* were studied, coming from Colorado, Arizona and Utah, and three figures represent all the variations found. These are practically all in the size of the penis sheath, though none is in the least like that of *laudabilis*. The differences in the *uncus* are due to differences of position, the drawings having been made with a camera lucida. Attention is especially directed to the uniformity of the outer angle of clasper at point of constriction.

Two examples a ♂ and ♀ from Kaslo, B. C., do not fit into the series of *strigicollis* and, in my opinion, represent a good species.

Mamestra restora n. sp.

Head and collar pale greenish over white; palpi black at sides, the small terminal joint pale; vertex with an admixture of black scales. Collar with a distinct black band crossing above the middle. Thoracic disc mottled with black, white and pale green. Primaries, the pale areas light greenish, basal and median lines white-filled, ornamentation otherwise black. All the lines geminate and broken. An irregular black spot at the termination of the basal line inferiorly. Median space mostly black, marked with mossy green below the sub-median vein. The outer part of wing is black powdered, forming a black patch at anal angle, more conspicuous than in its allies. The fringes are deeply marked with black and narrowly cut with white. Claviform deeper black, extending almost across the median space. Orbicular small, round, with a blackish central dot and a greenish annulus. Reniform large, superiorly dilated, annulate with white, with a mossy greenish filling. Secondaries smoky in both sexes; uniformly so in paler at base in ♂. Beneath, primaries blackish; secondaries with blackish powderings along costa and outer margin, a dusky discal spot and an extra-median line.

Expands 1.08–1.12 inches equals 27–28 mm.

Habitat: Kaslo, B. C., VII, 10, IX, 1.

One ♂ and one ♀ in good condition. Type of maculation like *strigicollis*, but darker throughout, the paler areas shaded with green, the anal angle of primaries with a dark blotch, secondaries dark in both sexes.

It is doubtful whether I would have dared to describe this as a distinct species in spite of its different appearance, were it not for the difference in the genitalia of the male. Comparison of figure 5, with figures 2, 3 and 4 will show to what I refer. In *restora* the harpes curve evenly to the narrowly extended tip, and form no obvious angle, while the extension of tip itself is shorter and broader. The claspers are also more slender and more separated than in the allied forms, and for the present I believe that we have a very good species to deal with, although undoubtedly a recent off-shoot from *strigicollis*.

Mamestra marinitincta Harvey, was described in 1875, in the Bull. Buf. Soc. Nat. Sci., II, 273, and is evidently a local offshoot from *strigicollis*, in a different direction from *restora*. Here the angle of harpes is intensified instead of lessened, and the extension of the tip is carried further. The penis sheath is very much elongated and more like *laudabilis;* but with a very long irregular series of short spinules running longitudinally. The small clasper has been reduced to a mere vestige, while the larger has not changed materially.

Superficially the wing form of *strigicollis* is held, while the median area is an exaggeration of the tendency to narrow it in *laudabilis*. Accompanying this is the evening of the median lines and the elimination of the second element, so that they are scarcely geminate except on costal area. Thus far the species is recorded from Texas only, and most of the examples are from the Belfrage collections in Bastrop Co. In my collection is one ♀ from Kerrville, and one ♀ labelled "Tenn.," out of the Kemp collection. These two examples are very similar to each other; but may possibly be distinct from *marinitincta*. I do not think they are, at present, and await further material for closer study.

Mamestra spiculosa Grote, is a species that has always been rare in collections and the two pairs now before me I owe to the kindness of Mr. Doll. The figure of the ♂ genitalia in my revision lacks detail, and a better drawing is presented here as an illustration of an intermediate form between the *olivacea* and *laudabilis* types;—the harpes of *illaudabilis* with the tip of *olivacea* indicated by the drawn out point. The clasper is long, slender and single.

In *Mamestra stricta* Wlk., and its variety *ferrea*, the structures become more compact except for the clasper, which is longer and more slender. I have twenty examples before me illustrating

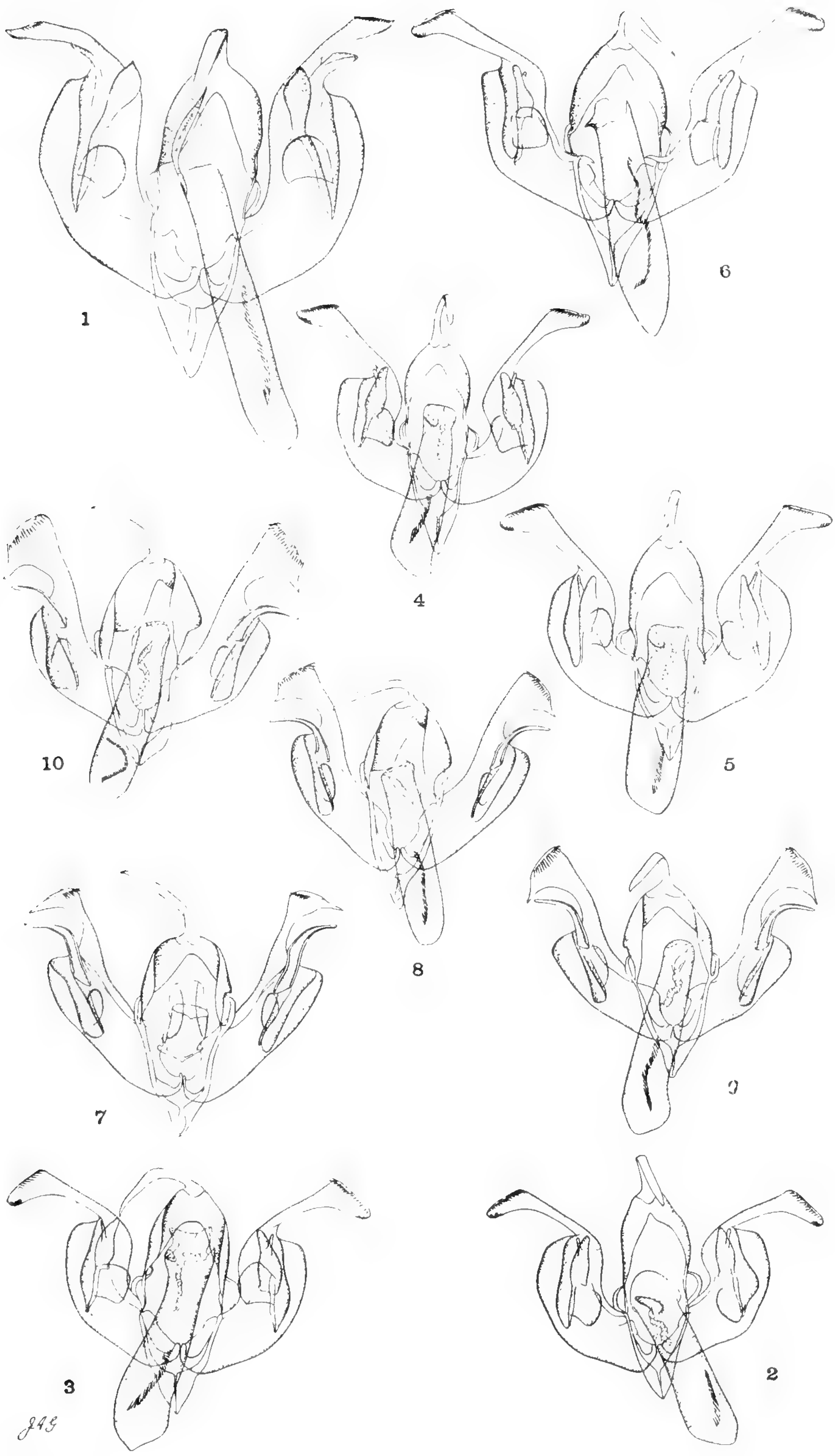
the gradations from the deep red brown to the yellowish brown type, and the species as a whole seems quite recognizable and, except for this variation in ground, very constant.

Mamestra circumcincta Smith, was described from two Californian examples representing the two sexes, which I placed with *stricta* on genitalic characters, while comparing it with *olivacea* in fascies. The ♂ type is in my collection, and another ♂ example recently received from San Francisco, California, makes re-examination possible, as well as a new figure of the ♂ genitalia available. Hampson in his Vol. V, p. 176, makes this a synonym of *stricta;* but in my opinion quite without warrant. The total habitus and ground color are different, while the differences pointed out in my original description are intensified in the fresh example which is darker and more smoky throughout. Neither example has in the secondaries any of that yellowish tinge that is in all specimens of *stricta* ever seen by me. As for the genitalia, I can claim very little for *circumcincta* as against *stricta.* The two are very much alike, and such differences as exist might easily be within range of variation. A comparison of figures 8 and 9 will make this clear.

Mamestra tenisca, recently described by me in the Proc. N. Y. Ent. Soc., is an intensified and enlarged *stricta*, and I have little doubt is mixed with the older species in collections; but I believe it to be well distinguished and take this opportunity to offer a figure of the male genitalia which, while preserving their close resemblance to those of *stricta*, depart noticeably from the type. Especial attention is directed on this point to the curved series of spinules on the penis sheath, as compared with those in *stricta* and *circumcincta*.

Explanation of Figures on Plate XXIII.

Fig. 1. Mamestra laudabilis, from N. Y., Ga., and Fla. specimens.
Fig. 2. Mamestra illaudabilis, from Ariz. and Denver, Colo., specimens.
Fig. 3. Mamestra illaudabilis, from Arizona, desert specimens.
Fig. 4. Mamestra illaudabilis, from Utah specimen.
Fig. 5. Mamestra restora: from type ♂.
Fig. 6. Mamestra maritinitincta: Texas example.
Fig. 7. Mamestra spiculosa: Arizona.
Fig. 8. Mamestra stricta.
Fig. 9. Mamestra circumcincta.
Fig. 10. Mamestra tenisca: from one of the para-types.



J. B. Smith.

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THE PALPI OF MALE SPIDERS.

By John Henry Comstock.

INTRODUCTION.

The remarkable modification of the palpi of the males of spiders into organs for the transference of the seminal fluid to the female at the time of pairing of the sexes attracted the attention of naturalists at a very early date; and the great variety of forms presented by these organs has led systematists to make much use of them in taxonomic work. In practically all of the more important works on the classification of spiders there are figures and descriptions of the palpi of males.

Notwithstanding the general recognition of the value of these organs for taxonomic purposes our knowledge of their structure is very inadequate. Several important contributions to this subject have been published and are well known, notably those of Westring ('61), Menge ('66), Bertkau ('75 and '78), Wagner ('87), Van Hasselt ('89), and Chamberlin ('04 and '08). Still we find, even in the more recent publications, figures of palpi given with almost no effort to identify their parts; and even when some of the parts are named we find different terms applied to homologous parts in the descriptions of different genera.

The necessity of selecting from the many terms that have been proposed for parts of the palpi, a set to be used in a handbook of North American Spiders that the writer has in preparation, and the need of terms for parts that have not been described, has led to the preparation of this paper. It is hoped that the publication of it may tend to bring about a greater uniformity in nomenclature and an increased use in systematic works of the extremely valuable characters presented by these organs.

THE MORE GENERALIZED TYPES OF PALPI.

In all spiders the external opening of the reproductive organs of the male is on the lower side of the adbomen near its base, in the epigastric furrow. Some time before pairing the seminal fluid is emitted from this opening and is stored in a tubular cavity in an appendage of the last segment of the palpus, where it is retained until the pairing of the sexes, and from which it then passes to the spermathecæ of the female. As the object of this paper is purely morphological the details of this transference of the sperm will not be discussed here; the reader is referred to the recently published papers by Montgomery ('03 and '10) for a review of the subject and for an account of original observations.

FIG. 1. Tarsus of *Filistata hibernalis*; 1, lateral aspect; 2, oblique view; 3, mesal aspect.

FIG. 2. Diagram of the receptaculum seminis.

The genital appendage of the palpus of the male is exceedingly complicated in structure in the more specialized spiders, as in the Argiopidæ; but it is comparatively simple in some of the more generalized families. A few illustrations of the simpler forms will be given here.

THE FILISTATA TYPE OF PALPUS.—In *Filistata hibernalis*, which is a very common house spider in the South, is found the most simple type of male palpus that I have seen among spi-

ders. In the males of this species, the distal end of the last segment of the palpus, the tarsus, contains a coiled tube (Fig. 1); this is the *receptaculum seminis* (Wagner '87). The proximal portion of this tube is slightly enlarged and ends blindly; the distal part is slender and extends through a slender, twisted prolongation of the tarsus ending at its tip by an open mouth. The modified terminal portion of the tarsus, which contains the receptaculum seminis, is the *genital bulb*. By looking directly at the tip of the palpus, instead of at one side of it, it can be seen that the base of the bulb is situated in a cavity in the end of the main part of the palpus (Fig. 1, *a.*). This cavity is the *alveolus* (Menge '66). The slender prolongation of the bulb, which contains the terminal portion of the receptaculum seminis is the *embolus* (Menge '66; *style*, Simon, '92). Except ing the specialization of the distal end of the tarsus, the segments of the palpus of *Filistata* resemble quite closely the corresponding segments of a leg, the relative length of the femur, patella, and tibia being quite similar; there is not the shortening of the tibia, which is so marked in many of the specialized forms, as in *Aranea* for example.

A study of the palpus of *Filistata* gives a clue to the probable course of the evolution of the genital bulb. It is evident that the bulb is a specialization of the tip of the tarsus, and its most striking feature is the presence within it of the coiled receptaculum seminis. Regarding the origin of the receptaculum seminis, the fact that it is furnished with a transversely striated intima, like the intima of a trachea, indicates that it is merely an invagination of the body-wall. In its primitive form, it was probably a cuplike depression in the tip of the tarsus.

In its most perfect form, as seen in the more specialized spiders, the receptaculum seminis consists of three quite distinct parts: first, the proximal end of it, the *fundus*, is enlarged so as to form a pouch, the wall of which is more delicate than that of the other parts (Fig. 2, *fu.*); I have not been able to see tænidia in the intima of this part, and infer that it serves as a compressible bulb; second, the intermediate portion, the *reservoir*, is a large coiled tube occupying the middle division of the genital bulb (Fig. 2, *res.*), in this part the tænidia of the intima are well-developed and are sometimes very prominent; third, the terminal portion constitutes the *ejaculatory duct*; this is the slender tube traversing the apical division of the bulb (Fig. 2,

ej. d.); the wall of this duct is often dark in color, which renders it easy to trace the course of the duct in an expanded bulb.

The tracing of the course of the ejaculatory duct is often the only method by which the embolus can be recognized in a complicated palpus; for when the embolus is small or when it is lamelliform a slender apophysis may be mistaken for it. Even Menge ('66), who proposed the term embolus for this part labels the terminal apophysis as embolus in several of his figures of *Epeira*.

Fig. 3. Palpus of *Hypochilus thorelli*.

Fig. 4. Palpus of *Loxosceles rufescens*.

There is no reason to believe that the lumen of the receptaculum seminis communicates with the body cavity; the *meati sanguinis* described by Wagner ('87) do not exist.

After the stage represented by *Filistata* had been reached, a shifting in the position of the bulb occurred in most spiders. Instead of occupying a terminal position, at the tip of the tarsus, it has moved to one side of the tarsus in all spiders known to me except *Filistata*. In the tarantulas and in *Hypochilus thorelli*, the most generalized in many respects of the true spiders,

the genital bulb is nearly terminal but is, nevertheless, distinctly on one side of the tarsus (Fig. 3). In other spiders it has moved to a greater or less extent towards the base of the tarsus, which it has nearly reached in many, as for example in *Loxosceles rufescens* (Fig. 4). It has been suggested by Nelson ('09) that this shifting of the position of the bulb is for the protection of it from mechanical injury.

In *Hypochilus* (Fig. 3) and in *Loxosceles* (Fig. 4), the alveolus is comparatively small; but in many spiders it is large, resulting in the tarsus being more or less cuplike in form; this is shown in some of the figures of the more specialized palpi given later. This cuplike form of the tarsus as distinguished from its appendage, the genital bulb, suggested for it the name *cymbium* (Menge '66), which is the classical name of a small drinking vessel. The term *lamina*, proposed by Westring ('61) antedates cymbium; but I have adopted the later term, as it is the one in general use.

The well-known fact that tarsal claws do not exist on the palpi of male spiders is easily understood if we regard the genital bulb as a specialization of the tip of the palpus, as is indicated by the structure of the palpus of *Filistata* described above. Sometimes, as in *Lycosa*, the tip of the cymbium bears one, two, or three stout spines; these have been regarded as "transformed claws" (Chamberlin '08); it seems more probable for the reason given above, that these are secondarily developed structures instead of vestigial claws; in fact there are frequently strong spines distributed over the surface of the cymbium.

The genital bulb in *Filistata* is helicoid; this is due, so far as the larger basal part is concerned, to the fact that the wall of it is molded over the coiled receptaculum seminis; but the twisting of the bulb is continued to the tip of the embolus, although in this part, the receptaculum seminis is not coiled but extends in a nearly direct line. I know of no other case where the helicoid form of the genital bulb is so well-marked as here; but there is always a more or less spiral arrangement of parts.

THE TARANTULA TYPE OF PALPUS.—In those spiders that are commonly known in this country as tarantulas, and which represent the more generalized of the two principal divisions of the order Araneida, there exists a comparatively simple type of

palpus; but in none of them that I have seen, or of which I have seen figures, is it as generalized as is the palpus of *Filistata*.

In the palpi of the tarantulas, the genital bulb has migrated to one side of the tarsus; but it is still near the tip of this segment of the palpus (Fig. 5). A striking feature of the bulb is that it is divided into two distinct segments. The smaller basal segment may be termed the basal division of the bulb (Fig. 5, *b. d.*). The larger segment consists of two parts: a large stout part, which may be termed the middle division of the bulb (Fig. 5, *m. d.*), and a slender terminal portion, which may be termed the apical division of the bulb (Fig. 5, *a. d.*); there is, however, no distinct line between the middle and the apical divisions, the one gradually merges into the other; but in the more specialized palpi these two divisions are distinctly separated.

FIG. 5. Tarsus of *Eurypelma*.

FIG. 6. Genital bulb of *Eurypelma californicum*.

In the articulating membrane which joins the bulb to the tarsus, there is on one side a distinct sclerite, which can be seen by removing the bulb from the alveolus (Fig. 6, *pet.*); this is doubtless homologous with what has been termed the *petiole* (Chamberlin '04) in more specialized palpi.

The greater part of the wall of the bulb in the tarantula type of palpus is very densely chitinized but there is a longitudinal area on the concave side of the middle and apical divisions which is comparatively soft (Fig. 6, *p. p.*); it may be that this part is distended by blood pressure at the time of pairing, as is the hæmatodocha in the more specialized palpi; but upon this point I have no data. This soft strip may correspond to that portion of the spiral type of embolus, described later, that I have designated the *pars pendula*.

THE PALPUS OF LOXOSCELES.—In certain genera of the true spiders, the palpi are as simple as in the tarantula type. In *Loxosceles* of the family Scytodidæ, for example (Fig. 4), although the bulb has migrated nearly to the base of the tarsus; the bulb itself is very simple in structure. The basal division of the bulb is inconspicuous; the middle division is nearly spherical, and the apical division is long and slender. Here the receptaculum seminis is differentiated into the three parts described above; the reservoir is large, while the ejaculatory duct is very slender.

THE PALPUS OF DYSDERA.—In the family Dysderidæ two quite distinct types of palpi occur. In *Ariadna* the palpus resembles very closely that of *Loxosceles;* but in *Dysdera* it is of a very different form (Fig. 7); this is due to the fact that the apical division of the bulb is not slender, and is sharply differentiated from the middle division, its wall being much less densely chitinized. But there is on each margin a distinct sclerite; and this part of the bulb bears distinct apophyses. At the tip of the apical division there appears to be the beginning of a separation into embolus and conductor.

FIG. 7. Palpus of *Dysdera interrita*

A summary of the parts of the tarsus in the more generalized types of palpi of males is shown by the following table:

- Body of tarsus or cymbium, containing the alveolus.
- Genital bulb.
  - Internal parts.
    - Receptaculum seminis.
      - Fundus.
      - Reservoir.
      - Ejaculatory duct.
  - External parts.
    - Petiole.
    - Basal division.
    - Middle division.
    - Apical division or embolus.

THE INTERMEDIATE TYPES OF PALPI.

There are palpi which hold an intermediate position as regards complexity of structure between the comparatively simple tarantula type and the exceedingly complex forms to be described later. These intermediate types occur in widely separated portions of the araneid series; but agree in their more essential characteristics; for sake of brevity, I will discuss only a few examples of the intermediate types; and will then pass to a description of forms in which the maximum number of parts is found.

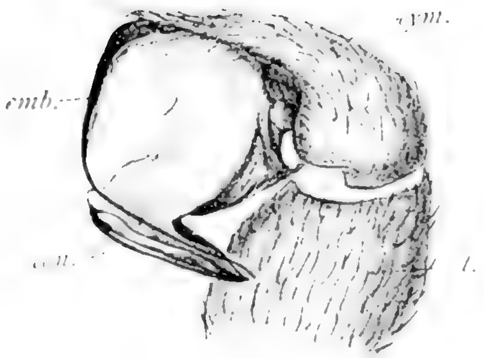

FIG. 8. Tarsus of *Atypus bicolor*.

FIG. 9. Genital bulb of *Pachygnatha*, extended.

The most important characteristic of these intermediate types is that the apical division of the bulb is separated into two, more or less nearly, parallel parts. One of these parts contains the ejaculatory duct of the receptaculum seminis, this is the *embolus* (Menge '66); the other is intimately associated with the embolus and is known as the *conductor of the embolus*, or the *conductor of the style*, or, simply, as the *conductor*.

A comparatively simple example of this group of palpi is that of *Atypus bicolor*. Here the terminal part of the con-

ductor is a broad concave plate (Fig. 8, *con.*), in which the terminal portion of the embolus rests.

A more complicated form of the apical division of the bulb exists in *Hypochilus thorelli* (Fig. 3). Here the embolus is coiled about the conductor, the terminal part of which is concave so as to support the terminal portion of the embolus; the tip of the conductor bears a delicate membranous flap.

In *Hypochilus* the tarsus bears a branch which supports a prominent bunch of bristles (Fig. 3, *p. c.*); this may be a rudimentary form of paracymbium, a part that is well developed in *Pachygnatha*.

A somewhat similar condition exists in *Pachygnatha* (Fig. 9). Here the proximal part of the embolus is coiled about the conductor, which is a broad twisted plate; and the terminal portion of the embolus is supported by the corresponding part of the conductor. When at rest the apical division of the bulb rests in the concave tip of the cymbium; but in the specimen figured the bulb has been extended so to show the parts better; and the embolus and conductor have been separated at the tip.

In *Pachygnatha* the tarsus is divided into two distinct parts, which are joined by a movable articulation at the base. The larger part is the cymbium (Fig. 9, *cym.*) the smaller part, the *paracymbium* (Menge '66) or the accessory branch of the tarsus (Simon '92) (Fig. 9, *p. c.*). The cymbium and the paracymbium resemble the other segments of the palpus in the nature of their cuticula and in the fact that they are clothed with hairs.

The term conductor is in general use and was substituted for the term *spermophorum* of Menge, which was suggested by a misconception of the function of this part. As to the particular part to which the term should be applied there is no doubt. Menge ('66, Plate 15) clearly indicates, in his figures of the palpus of *Tetragnatha extensa*, the part to which he applied the term spermophorum; and the term conductor must be applied to the homologous part whenever it is used. This, however, has not been done; in many descriptions an entirely different part has been termed the conductor, merely because it is more or less nearly parallel with the embolus. A discussion of the function of the conductor is given later.

THE MORE SPECIALIZED TYPES OF PALPI.

In the development of the bulb of the male palpus in the more specialized families of spiders there has been evolved an exceedingly complicated organ, which is difficult to understand, on account of its small size and the fact that when at rest it is compactly folded. Fortunately when such a palpus is boiled in a solution of caustic potash (10%) the bulb expands so that its parts can be seen; and if preserved in glycerine, it remains flexible, so that it can be easily manipulated. The expanded bulbs figured below were prepared in this way. Even with the best of preparations, it is sometimes difficult to make out the relation of parts; this can be most easily accomplished by the use of a stereoscopic binocular microscope.

The extreme specialization of the palpi of males is marked chiefly by the development of hæmatodocha, to be described later, and by an increase in the number of distinct parts and appendages of the bulb. The maximum degree of specialization is to be found in the Araneinæ, of which the palpi of several species of *Aranea* are described later. The understanding of the relation of the parts of the bulb in this genus will be facilitated by a study first of a more simple form, such as is found in the Linyphiidæ.

THE LINYPHIA TYPE OF PALPUS.—The very common *Linyphia phrygiana* will serve as an example of the Linyphiidæ.

As in *Pachygnatha*, just described, the body of the tarsus of *Linyphia* consists of two parts; the *cymbium* (Fig. 10, *cym.*), and the *paracymbium* (Fig. 10, *p. c.*). The *alveolus* is a circular cavity near the base of the cymbium.

When the bulb is expanded, the three divisions of it are distinctly separated, there being a slender neck between the basal division (Fig. 10, *b. d.*) and the middle division (Fig. 10, *m. d.*), and also a similar slender neck between the middle division and the apical division (Fig. 10, *a. d.*).

The wall of the basal division of the bulb consists of two parts; the basal hæmatodocha, and the subtegulum.

The basal hæmatodocha.—The genital bulb is attached to the cymbium, within the alveolus, by means of a saclike structure, which, ordinarily, is inconspicuous or completely concealed by other parts of the bulb, but which is very conspicuous in the expanded bulb (Fig. 10, *b. h.*). This has been named the

hæmatodocha from the fact that at the time of pairing it is distended with blood (Wagner '97). The wall of the hæmatodocha appears to consist of elastic connective tissue; hence the name *spiral muscle* applied to it by Menge is inappropriate. In fact no muscle tissue has been found within the genital bulb. As similar extensible blood-sacs are present in more distal parts of the bulb of many spiders, I suggest that this one be termed the *basal hæmatodocha*.

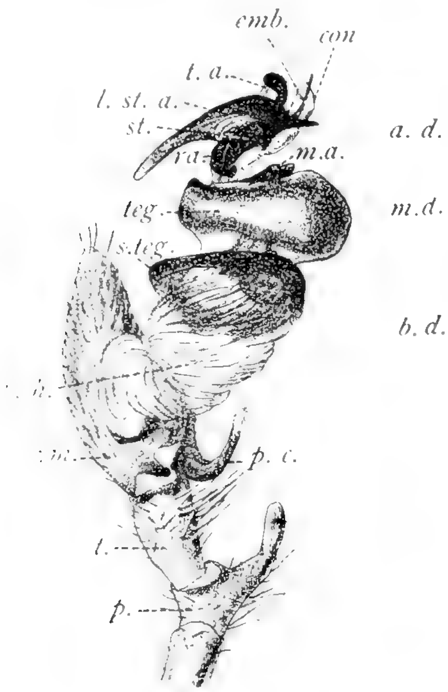

Fig. 10. Expanded bulb of *Linyphia phrygiana*.

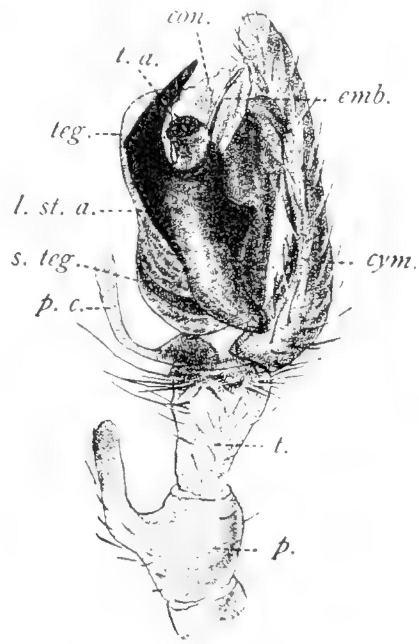

Fig. 11. Palpus of *Linyphia phrygiana*

The subtegulum.—The proximal end of the basal hæmatodocha is attached to the cymbium, the distal end, to a ringlike sclerite, for which I propose the term *subtegulum* (Fig. 10, *s. teg.*). The existence of a sclerite in this position was indicated by Wagner, and it is lettered in his figures *s. teg.*, but its ringlike form has not been described; in fact, Wagner states that the hæmatodocha ends in the tegulum.

The middle division of the bulb.—The middle division of the bulb (Fig. 10, *m. d.*) is that part which contains the chief portion of the receptaculum seminis, the *reservoir*; its wall is the tegulum, and it bears an appendage, the median apophysis.

The tegulum.—The term tegulum was applied by Wagner to all of the more densely chitinized parts of the wall of the genital bulb; but as it is desirable that the different sclerites should

bear distinctive names, I propose that this term be restricted to the sclerite that forms the wall of the middle division of the bulb. In *Linyphia*, the tegulum, in this restricted sense is a ringlike sclerite (Fig. 10, *teg.*).

The median apophysis.—Arising within the distal margin of the tegulum there is an appendage, only the tip of which is shown in the view of the bulb figured here (Fig. 10, *m. a.*); this is the *median apophysis.* In many spiders this appendage is very conspicuous; and to it have been applied several names. In fact in several instances a writer has applied different names to this part in his descriptions of different genera. Among the names that have been applied to it are *lamella characteristica* and *apophysis mediana* (Chyzer et Kulczynski '91), *clavis* and *unca* (F. O. Pickard-Cambridge '97–'05), and *scopus* (Chamberlin '04). The term median apophysis occurs frequently in descriptions, and is the older name for this part.

The median apophysis is articulated to the middle division of the bulb near the point from which the apical division arises; and in some cases, as in *Aranea*, it appears to be more closely articulated with a basal segment of the apical division, the radix, than it is with the tegulum.

The apical division of the bulb.—This division includes that portion of the bulb which lies distad of the middle division; it consists of two subdivisions: the conductor and the embolic subdivision. The embolic subdivision is traversed by the ejaculatory duct and is composed of several distinct parts. In fact the multiplication of parts of the embolic subdivision is the most characteristic feature of the more specialized types of palpi as contrasted with the intermediate types described above.

The conductor.—The conductor (Fig. 10, *con.*) is easily recognized by its relation to the embolus, which rests upon it, and by its membranous texture. Its attachment to the middle division of the bulb is by means of an exceedingly delicate membrane.

In *Linyphia* the embolus rests upon the conductor throughout its length; but in many genera the palpi of some of which are described later, the function of the conductor is evidently to protect the tip of the embolus in the unexpanded bulb. In many cases the embolus is very long while the conductor is short; but in every case the embolus in the unexpanded bulb occupies such a position that its tip is protected by the conductor.

In most cases the conductor can be recognized at a glance by its peculiar texture; sometimes it is chitinized to a considerable extent, but even then it usually has a membranous margin; and in any case it can be recognized by its relation to the tip of the embolus in the unexpanded bulb.

The embolic subdivision.—Closely connected with the membranous base of the conductor is the base of a separate subdivision of the apical division of the bulb; as this portion bears the embolus it may be termed the *embolic subdivision.*

The radix and the stipes.—Immediately following the membranous neck that connects the middle and the apical divisions of the bulb and parallel with the membranous base of the conductor, there are two segments of the embolic subdivision; to the basal one of these I apply the term *radix* (Fig. 10, *ra.*); and to the second, the term *stipes* (Fig. 10, *st.*). For a more distinctly segmented condition of the base of the embolic subdivision see the figures of *Aranea circulata* given later (Fig. 18 and 19), where the corresponding parts bear the same letters.

The embolus.—The organ through which the ejaculatory duct opens, the *embolus*, is comparatively simple in *Linyphia*, being a short spinelike part (Fig. 10, *emb.*).

The lateral subterminal apophysis.—In *Linyphia phrygiana* there is developed a remarkable platelike apophysis, which serves to protect the exposed face of the unexpanded bulb. In Figure 10 (*l. st. a.*), only the edge of this apophysis is shown; but in Figure 11, the broader face of it is represented. I designate this the *lateral subterminal apophysis* as it occurs on the lateral aspect of the unexpanded bulb, and also to distinguish it from an apophysis developed on the opposite face of the bulb in a subterminal position, which occurs in certain other genera.

The terminal apophysis.—The embolic subdivision ends in a strongly chitinized lobe, which may be designated the *terminal apophysis* (Fig. 10, *t. a.*). To apophyses of this kind Menge applied the term *retinacula;* but as this term predicates their function, which in some cases is obviously not that implied by the name, I prefer apophysis with a modifying term indicating the position of the particular apophysis described.

The Aranea Type of Palpus.—I have selected the palpus of *Aranea frondosa* (*Epeira strix*) as an example of an extremely specialized palpus. In Figure 12 the entire palpus, with the bulb unexpanded, is represented slightly twisted so as to show

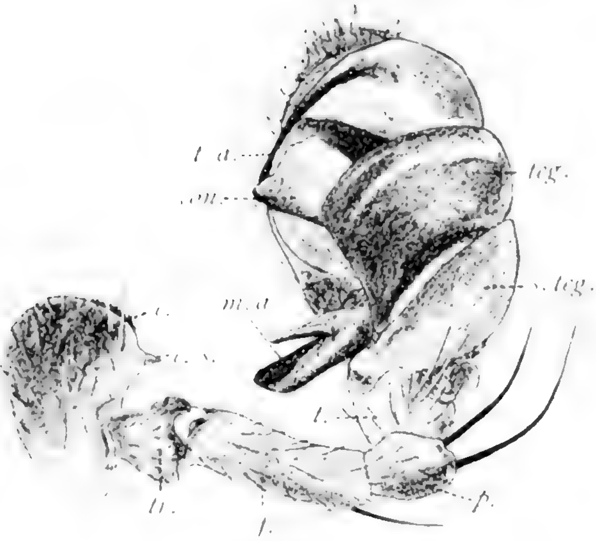

Fig. 12. Palpus of *Aranea frondosa.*

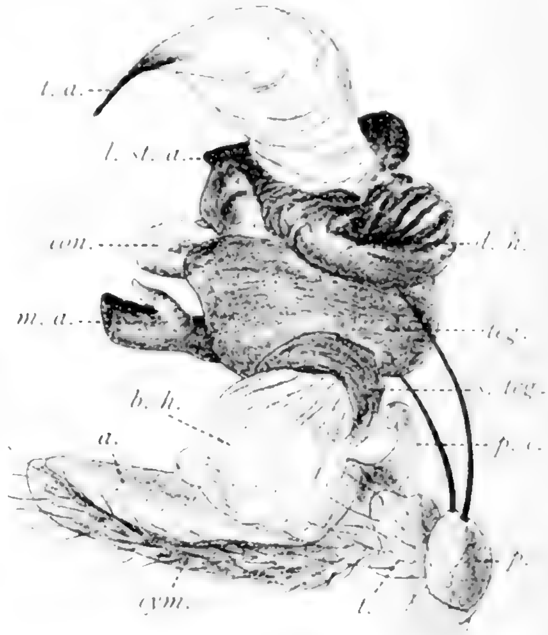

Fig. 13. Lateral aspect of an expanded bulb of *Aranea frondosa.*

Fig. 14. Mesal aspect of an expanded bulb of *Aranea frondosa.*

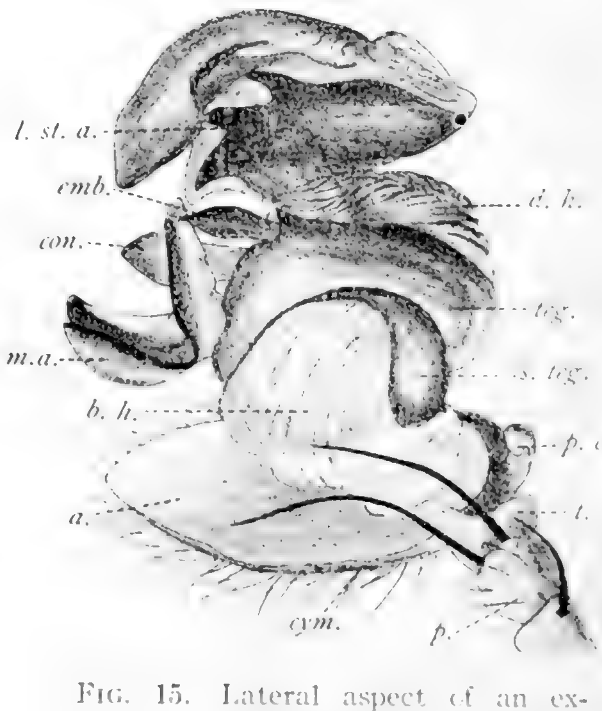

Fig. 15. Lateral aspect of an expanded bulb of *Aranea ocellata.*

the ventral aspect of the proximal segments and the lateral aspect of the bulb.

The proximal segments of the palpus.—This account of the palpi of male spiders is devoted almost entirely to a discussion of the parts of the tarsus, the proximal segments being well-understood; there are, however, a few features of these segments in the aranea type that merit attention here.

Upon the coxa there is a prominent spur, *the coxal spur* (Fig. 12, *c. s.*); and upon the inner side of the femur near its base, there is a groove, the *femoral groove*, into which the coxal spur fits when the palpus is extended forward. The presence or absence of this spur and groove is an important generic characteristic in the Araneinæ.

The patella bears two prominent spines at its apex (Fig. 12, *p.*). This is also true in the males of several other genera; but in the greater number of genera of the Araneinæ there is only a single spine in this position.

The most striking feature of the tibia is its shortness, being of about the same length as the patella.

The tarsus.—As in *Linyphia*, the tarsus of *Aranea* consists of two parts; the cymbium and the paracymbium. But in *Aranea* the paracymbium (Fig. 13, *p. c.*) is merely a prominent apophysis arising from the base of the cymbium and is not articulated with the cymbium by a movable joint as in *Linyphia* and in *Pachygnatha*. The alveolus is much more extended than it is in *Linyphia;* here it occupies nearly the whole length of the cymbium (Fig. 13, *a.*).

The unexpanded bulb.—In the unexpanded bulb of *Aranea frondosa*, the subtegulum (Fig. 12, *s. teg.*), tegulum (Fig. 12, *teg.*), and a terminal lobe of the apical division of the bulb, bearing a long and slender terminal apophysis (Fig. 12, *t. a.*) are visible. Two prominent appendages can also be seen; the median apophysis (Fig. 12, *m. a.*) and the conductor (Fig. 12, *con.*).

The expanded bulb.—Two figures of the expanded bulb are given here; Figure 13 represents the lateral aspect of the bulb, the aspect that is exposed when the bulb is not expanded; and Figure 14, the mesal aspect, the one that is next the cymbium in the unexpanded bulb.

The basal hæmatodocha is essentially the same as in *Linyphia* (Fig. 13 and 14, *b. h.*).

The subtegulum is a ringlike sclerite but its form is like that of a seal-ring being narrow on the mesal aspect of the bulb and wide on the lateral aspect (Fig. 14, *s. teg.*). This wider part of the subtegulum is all of it that is commonly observed and has been termed the *lunate plate* (Chamberlin '04).

The specimen represented in Figure 14 was more fully expanded than that used for Figure 13. In the more expanded specimen there is evident a large hæmatodocha between the subtegulum and the tegulum; this I designate the *middle hæmatodocha* (Fig. 14, *m. h.*). The dark axial object seen through the wall of the middle hæmatodocha is the fundus of the receptaculum seminis (Fig. 14, *fu.*).

The tegulum is also a ringlike sclerite, which is broad on the lateral aspect of the bulb (Fig. 13, *teg.*), and is narrow on the mesal aspect (Fig. 14, *teg.*).

The median apophysis (Figs. 12 and 13, *m. a.*) is a conspicuous appendage, which projects from the ventral side of the bulb. Although the position of this appendage in *Linyphia*, in which the middle and apical divisions of the bulb are distinctly separated, shows that the median apophysis is an appendage of the middle division, in *Aranea* it appears to be articulated with the base of a proximal segment of the apical division, the radix.

The conductor (Fig. 14, *con.*) arises at the base of the apical division and is closely connected with the tegulum.

The radix (Fig. 14, *ra.*) is much larger than in *Linyphia*. Here it forms the wall of one side of the basal segment of the embolic subdivision of the apical division. That this is the case is more clearly shown in the bulb of *Aranea circulata* (Fig. 18 and 19, *ra.*), where the segmentation of the embolic subdivision is much more marked.

The stipes (Fig. 14, *st.*) is also much larger than in *Linyphia;* it is articulated with the distal end of the radix. Like the radix, the stipes forms the walls of one side of a segment of the embolic subdivision of the bulb, a fact which is also well shown in the bulb of *Aranea circulata* (Fig. 18 and 19, *st.*).

The embolus is borne by the embolic subdivision distad of the stipes; it projects ventrad between the distal end of the stipes which is mesad of it, and the conductor, which is laterad of it in the unexpanded bulb. In the specimen represented in Figure 14, the distal end of the stipes and the embolus have been pushed away from the conductor in the expanding of the bulb.

The distal hæmatodocha.—The most striking feature of the embolic subdivision in the aranea-type is the presence of a large hæmatodocha, which when expanded over-shadows all other parts. This hæmatodocha I designate the *distal hæmatodocha* (Fig. 13 and 14, *d. h.*). It is doubtless due to the development of this hæmatodocha that the radix and the stipes are restricted to one face of their respective segments of the apical division in *Aranea frondosa*, the remaining parts of the wall of these segments forming a part of the distal hæmatodocha.

The mesal subterminal apophysis.—On the mesal aspect of the bulb, there arises from the distal hæmatodocha a prominent apophysis (Fig. 14, *m. st. a.*); this may be termed the *mesal subterminal apophysis.*

The lateral subterminal apophysis.—On the lateral aspect there is also an apophysis borne by the distal hæmatodocha (Fig. 13, *l. st. a.*); this may be termed the *lateral subterminal apophysis.*

The terminal apophysis.—In *Aranea frondosa*, the tip of the embolic subdivision of the bulb ends in a spearshaped apophysis (Fig. 13, *t. a.*); this may be termed the *terminal apophysis.*

The Palpus of Aranea Ocellata.—A glance at the palpus of *Aranea ocellata* (*Epeira patigiata*) will show that it is of essentially the same type as that of *Aranea frondosa* but is different in some details. It is figured here to illustrate the kind of variations in form that serve to distinguish closely allied species (Fig. 15.) The median apophysis differs markedly in form from that of *A. frondosa;* the tegulum bears a small but distinct apophysis; the lateral subterminal apophysis bears two prominent teeth; and the terminal apophysis is lacking, the embolic subdivision ending in a blunt lobe.

The Palpus of Aranea Circulata.—The most striking modification of the aranea type of palpus, taking the palpus of *Aranea frondosa* as typical, is that of *Aranea circulata*, which is the most complex palpus that I have studied. In the unexpanded bulb, there appears to be no resemblance to the bulb of *Aranea frondosa.* In *Aranea circulata* (Fig. 16 and 17), the bulb is very large and the cymbium comparatively small and narrow (Fig. 17, *cym.*). The basal hæmatodocha (Fig. 16, *b. h.*) is conspicuous, which is the result of the other parts of the bulb being twisted into unusual positions. The median apophysis is large and projects beyond the tip of the bulb (Fig. 16, *m. a.*).

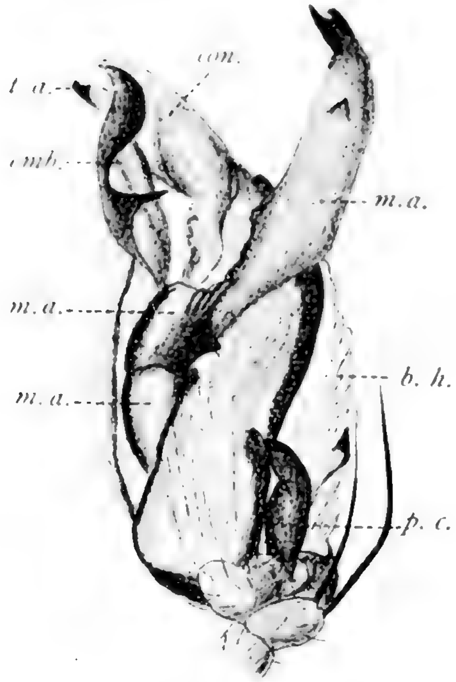

Fig. 16. Unexpanded bulb of *Aranea circulata*.

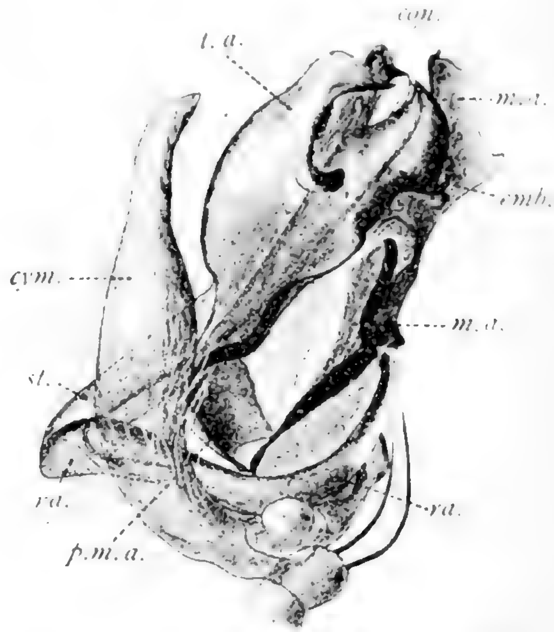

Fig. 17. Unexpanded bulb of *Aranea circulata*.

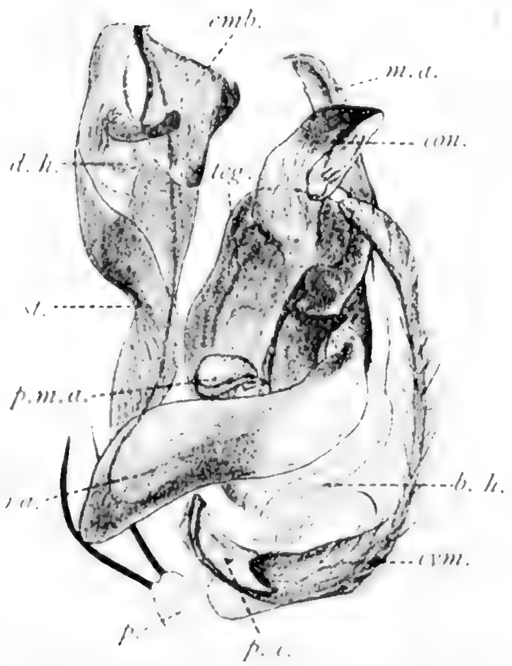

Fig. 18. Expanded bulb of *Aranea circulata*.

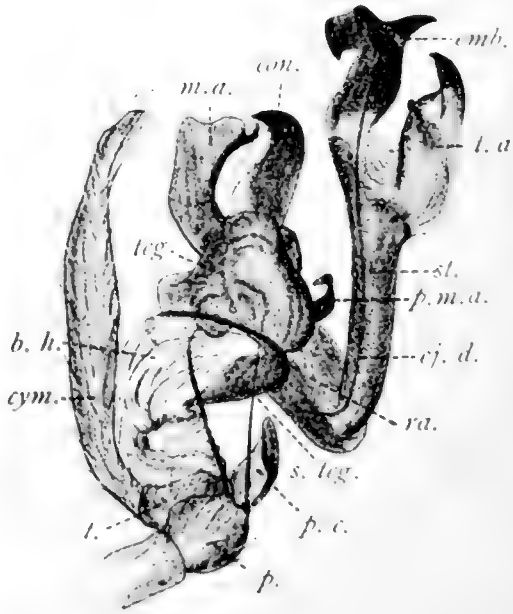

Fig. 19. Expanded bulb of *Aranea circulata*.

But the most remarkable feature is an elbowed structure on the mesal aspect at the base of the bulb (Fig. 17). The fact that the ejaculatory duct can be traced throughout the length of this elbowed structure gave the first definite clew to the relations of the parts of the bulb. The part containing the ejaculatory duct evidently pertains to the apical division of the bulb, although it appears to arise from the base of the bulb.

When the bulb of *Aranea circulata* is expanded and untwisted, as occurs in the process of expansion, the relation of the parts is more easily seen. Figures 18 and 19 represent two views of a preparation of this kind. If Figure 19 be studied it will be seen that the relations of parts are essentially the same as in *Aranea frondosa* (Fig. 14); the basal hæmatodocha, subtegulum, and tegulum follow in the same sequence; the median apophysis and the conductor project from beneath the tegulum in the corresponding positions, and the elbowed structure, which in the unexpanded bulb appears to arise at the base of the bulb is here clearly seen to be the embolic subdivision of the bulb. The most remarkable differences are the lack of a prominent distal hæmatodocha and the fact that the radix (Fig. 19, *ra.*) and stipes (Fig. 19, *st.*) are each a complete cylinder, instead of merely forming one face of the wall of a segment of the apical division, as in *Aranea frondosa*. At the distal end of the stipes, between this part and the embolus and the terminal apophysis, there is a vestigial distal hæmatodocha (Fig. 18. *d. h.*).

In this species there is an apophysis which like the median apophysis is joined by a flexible articulation to the tegulum within the cuplike cavity formed by the distal margin of the tegulum (Fig. 17 and 19, *p. m. a.*); this may be termed the *paramedian apophysis*. As I have not found this apophysis in other palpi, I do not consider it a fundamental part.

THE PALPUS OF ARANEA GIGAS.—The preceding species, *Aranea circulata*, and several others, have been separated from *Aranea* by Pickard-Cambridge and placed in the resurrected genus *Eriophora* of Simon. The peculiar form of the genital bulb in *Aranea circulata* appears to sustain this separation. But in the palpus of *Aranea gigas* (Fig. 20 and 21) we find a form intermediate between the aranea type and what may be termed the eriophora type.

In the unexpanded bulb of *Aranea gigas* (Fig. 20) the parts are twisted so as to render the basal hæmatodocha conspicuous

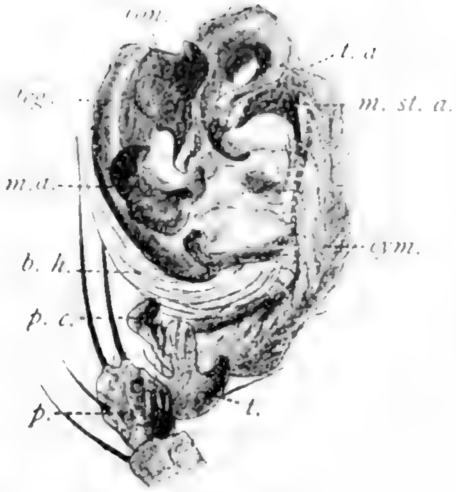

FIG. 20. Unexpanded bulb of *Aranea gigas*.

FIG. 21. Expanded bulb of *Aranea gigas*.

FIG. 22. Expanded bulb of *Dolomedes fontanus*.

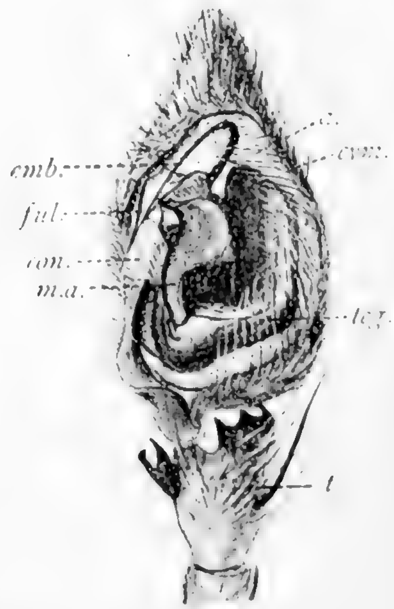

FIG. 23. Unexpanded bulb of *Dolomedes fontanus*.

as in *Aranea circulata;* but otherwise there is little similarity in appearance to either this species or to *Aranea frondosa.*

In the expanded bulb (Fig. 21) it can be seen that the embolic subdivision, is intermediate in form between the two types, resembling the aranea type in having a large distal hæmatodocha and a well-developed median subterminal apophysis; and resembling the eriophora type in the form of the embolus, which is lamelliform (Fig. 21, *2*). In the general view (Fig. 21) the embolus is covered by the tip of the stipes.

THE PISAURID TYPE OF PALPUS.—In the family Pisauridæ there is a type of palpus which, while it resembles the aranea type in its more general features, differs from that type in several important particulars. The palpus of *Dolomedes fontanus* (Fig. 22 and 23) may be taken as an example of this type.

A study of an expanded bulb of this species (Fig. 22) reveals the following characteristics: There is a well developed *petiole* of the bulb (Fig. 22, *pet.*), which, in this species, consists of two nodes with an unchitinized internode. The subtegulum bears very prominent *anelli* (Fig. 22, *an.*), which are described in a later paragraph. The *median apophysis* is prominent (Fig. 22, *m. a.*). The conductor (Fig. 22, *con.*) is extremely membranous. The *radix* and the *stipes* are not developed as distinct segments. The *embolus* is of the spiral type (Fig. 22, *emb.*) The *terminal apophysis* is modified into an organ for the support of the embolus (Fig. 22, *ful.*), which may be termed the *fulcrum* of the embolus. This type of terminal apophysis has been termed, incorrectly, the conductor. The true conductor in this species, as in all others studied, is an organ whose function is to protect the tip of the embolus in the unexpanded bulb. At the base of the terminal apophysis, at the point where the embolus arises, there is a lamelliform *lateral subterminal apophysis* (Fig. 22, *l. st. a.*).

In the unexpanded bulb (Fig. 23), the long *embolus* makes a curve in the distal end of the alveolus beyond the end of the bulb. The *fulcrum* is applied against the embolus on its concave side, and has a furrow on its distal face within which the embolus rests. The distal part of the *conductor* is wrapped about the tip of the combined embolus and fulcrum, serving, as in all other cases observed, as a protection to the tip of the embolus.

THE ANELLI OF THE SUBTEGULUM.—In *Aranea*, the chitinized part of the wall of the basal division of the bulb, the subtegulum, is reduced to a ringlike sclerite (Fig. 24, *1*.); but in certain other genera, the subtegulum is cup-shaped or basket-like. In *Agelena nævia* (Fig. 24, *2*), one side of the subtegulum is greatly thickened; at the proximal end of this thickening, which corresponds to the lunate plate, there is a condyle, which articulates with the petiole; and at the distal end, there is a condyle, which articulates with the tegulum. The other side of the cuplike subtegulum contains in its wall several parallel, incompletely ringlike sclerites; these may be termed the *anelli* of the subtegulum. In *Dolomedes fontanus* (Fig. 24, *3*), the anelli of the subtegulum are greatly thickened and form prominent projecting ridges.

It is probable that the presence of the anelli of the subtegulum, and their nature when present will afford characters of use for taxonomic purposes.

FIG. 24. Three kinds of subtegulum.

THE DIFFERENT TYPES OF EMBOLUS.—The form of the embolus varies greatly in different species of spiders. Two principal types can be recognized, the connate and the free; and the free type includes three subtypes.

The connate type of embolus.—In the connate type, the embolus is not separate from the middle division of the bulb but is merely a more slender continuation of it, as in the tarantulas, *Loxosceles* (Fig. 4), and *Ariadna*.

The free type of embolus.—In the free type of embolus, there are one or more movable articulations between the embolus and the middle division of the bulb. In the free type, the embolus varies greatly in form; but the different forms can be grouped under three heads: coniform, lamelliform, and spiral.

A coniform embolus.—In this type, there may be a broadly expanded base; but the projecting part of the embolus is a straight or slightly curved cone. The embolus of *Aranea frondosa* (Fig. 25, *1*) is an example of this type.

A lamelliform embolus.—In this type the embolus is flattened, and may bear a greater or less number of apophyses; an example of this type is found in *Lepthyphantes minuta* (Fig. 25, *2.*)

A spiral embolus.—In the spiral type, as seen in *Agelena*, for example, the embolus is long, slender and coiled; and, in a well-expanded specimen, it is seen to be composed of three distinct parts: first, the wall of the convex side is densely chitinized, forming a gutterlike sclerite, which may be termed the *trunk of the embolus (truncus)* (Fig. 25, *3*, *t. e.*); second, the greater part of the wall of the embolus is membranous, and forms a loose flap along the concave side of the organ, which contains the ejaculatory duct; this flap (Fig. 25, *3*, *p. p.*) may be designated the *pars pendula* of the embolus; third, at the distal end of the pars pendula, there is a triangular, chitinized area, through which the ejaculatory duct opens (Figs. 25, *3*, *a. s.*), this may be termed the *apical sclerite* of the embolus.

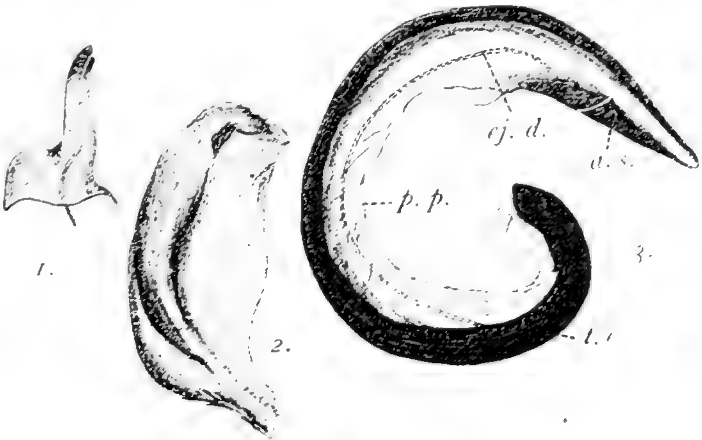

Fig. 25. Three types of embolus.

The pars pendula and the apical sclerite may be completely withdrawn into the trunk of the embolus, so that only the latter is visible; the embolus then appears to be merely a strongly chitinized style; it is in this condition that it is usually seen and described.

CONCLUSION.

In the preparation of this paper many palpi other than those figured here have been studied; and it is believed that the series examined has been sufficiently large to warrant the conclusions given regarding the fundamental parts of the genital bulb. There remains to be determined the manner in which the different types of palpi have been specialized in other families of the order, and the details of the modifications characteristic of genera. This, however, is too great an undertaking to be attempted at this time, and must be left for those who monograph the different families.

I wish, however, to urge the importance of describing palpi from expanded specimens. A large proportion of the figures of palpi that have been published, being of unexpanded examples show comparatively little of the structure of this organ. The labor involved in expanding the bulb of a palpus is very little; a preparation can be made in five minutes; and in no other way can so much be done to make possible a description that will describe.

The following tabular statement shows the relations of the fundamental parts of the tarsus in the more specialized types of palpi; not all of these parts are invariably present, and frequently subordinate apophyses are developed.

- Body of the tarsus.
  - Cymbium, containing the alveolus.
  - Paracymbium.
- Genital bulb.
  - Internal parts.
    - Receptaculum seminis.
      - Fundus.
      - Reservoir.
      - Ejaculatory duct.
  - External parts.
    - Basal division of the bulb.
      - Basal hæmatodocha.
      - Petiole.
      - Subtegulum.
        - Lunate plate.
        - Anelli of the subtegulum.
    - Middle division of the bulb.
      - Middle hæmatodocha.
      - Tegulum.
      - Median apophysis.
      - Paramedian apophysis.
    - Apical division of the bulb.
      - Conductor.
      - Embolic subdivision.
        - Radix.
        - Stipes.
        - Embolus.
          - Body of embolus.
          - Pars pendula.
          - Apical sclerite of the embolus.
        - Distal hæmatodocha.
        - Lateral subterminal apophysis.
        - Mesal subterminal apophysis.
        - Terminal apophysis, sometimes developed into a fulcrum.

In conclusion I wish to acknowledge the very efficient assistance in the preparation of this paper, of Miss Anna C. Stryke, who prepared the illustrations for it.

NAMES OF THE PARTS OF THE PALPUS AND ABBREVIATIONS USED FOR THEM IN THE ILLUSTRATIONS.

Accessory branch=paracymbium.
Alveolus, *a.*
Anelli of the subtegulum, *an.*
Apical division of the bulb, *a. d.*
Apical sclerite of the embolus, *a. s.*
Basal division of the bulb, *b. d.*
Basal hæmatodocha, *b. h.*
Clavis=median apophysis.
Conductor of the embolus, *con.*
Coxa, *c.*
Coxal spur, *c. s.*
Cymbium, *cym.*
Distal hæmatodocha, *d. h.*
Ejaculatory duct, *ej. d.*
Embolic subdivision of the bulb, *e. s.*
Embolus, *emb.*
Femur, *f.*
Fulcrum, *ful.*
Fundus of the receptaculum seminis, *fu.*
Lateral subterminal apophysis, *l. st. a.*
Lunate plate=subtegulum in part.
Median apophysis. *m. a.*
Mesal subterminal apophysis, *m. st. a.*
Middle division of the bulb, *m. d.*
Middle hæmatodocha, m. h.
Paracymbium, *p. c.*
Paramedian apophysis, *p. m. a.*
Pars pendula of the embolus, *p. p.*
Patella, *p.*
Peticle of the bulb, *pet.*
Radix, *ra.*
Receptaculum seminis, *r. s.*
Reservoir, *res.*
Scopus=median apophysis.
Spiral muscle=hæmatodocha.
Stipes, *st.*
Style=embolus.
Subtegulum, *s. teg.*
Tegulum, *teg.*
Terminal apophysis, *t. a.*
Tibia, *t.*
Trochanter, *tr.*
Trunk of the embolus, *t. e.*

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NORTH AMERICAN PANISCINI.

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INTRODUCTION.

The tribe Paniscini is rather a small one in this country, containing but two genera, and eleven species so far described. The external anatomy here given was prepared from our commonest species—Paniscus geminatus (Say)—added to by comparison in some respects with the corresponding structures in Opheltes glaucopterus (Linn). It was my intention when I commenced this paper to include a key to the species of Paniscus, but I have been unable to see specimens of all the species, and the entirely inadequate descriptions of several has made it impossible to prepare a key that would be strictly reliable. I have therefore included the original descriptions of the different species here, leaving it to others with better opportunities to prepare the key.

This paper has been prepared under the supervision of Dr. H. T. Fernald of the Massachusetts Agricultural College, and to him I wish to extend my heartiest thanks for his suggestions, verification of observations, and other assistance in the course of the work.

EXTERNAL ANATOMY.

HEAD.

The head is of medium size and of the hypognathous type. It is slightly higher than broad, and when viewed from the front appears nearly circular in outline. From above, it appears slightly bi-concave; the anterior concavity being lost at the level of the insertion of the antennae and below them.

The compound eyes are large, extending from the top of the head to a point almost touching the base of the mandibles. Looking from the front these organs occupy half or slightly more than half of the front of the head; from the side view the eye takes up about two-thirds the width. The anterior margin of the eye, about one-third the distance from the top, is sharply excavated which is very noticeable. The antennæ are inserted at the line of these two indentations or very near it. The lateral margins appear nearly straight. Above the point of concavity,

the eye which is elliptical in form extends toward the middle of the head, somewhat, thus making the distance between these organs at the vertex, a little less than at any other point.

The cheek, which lies behind the eye, is nearly uniform in width from the top to the base, and is only slightly narrower below where it extends slightly beneath the eye. The face in general is clothed with a short thick mat of sericeous pubescence.

CLYPEUS.

The clypeus, which is more or less irregular in outline, being rounded above (convex) and nearly straight along its free margin occupies about a third of the distance from the antennæ to the mandibles. On either side there is a projection, which extends just below the compound eyes, and about half way between the extremities of these projections and the dorsal edge of the clypeus are situated a pair of oval depressions, one on either side known as clypeal foveæ. The dorsal edge of the clypeus is marked by a transverse suture (or rather what was once apparently a suture, as there are no distinct sutures separating the clypeus from the frons) some little distance below the insertion of the antennæ. Between these there is quite a noticeable depression, the lower side of which is most pronounced.

FRONS.

The frons may be regarded as extending upward from the clypeus to the ocelli, with a downward extension on each side of the clypeus, where it appears to meet the cheek just below the eye. About two-thirds of the whole distance from the dorsal line of the clypeus to the ocelli, is the place of insertion of the antennæ. That portion of the frons, from the antennæ extending downward, projects in front of the level of the eye, while the portion above the antennæ is slightly sunken behind this level.

OCELLI.

The ocelli, which are of nearly equal size, are three in number, and are arranged to mark the corners of an equilateral triangle. The two lateral (posterior) ocelli nearly touch the compound eyes. An imaginary line passing through the posterior ocelli marks the vertex as treated in this paper. No sutures separating the vertex from the posterior portion of the head, above, of from the cheeks, behind the eyes, are present, and the limits of these parts are therefore somewhat indefinite.

The portion of the head, showing behind the compound eye, is termed the cheek, in this paper. The width of the cheek does not vary a great deal. The central portion, however, (that portion in the region of the attachment of the head to the thorax) is slightly wider than other parts.

LABRUM.

The labrum is attached to the lower, inner edge of the clypeus, leaving the outer edge of the clypeus well defined. In preserved specimens, the labrum is usually bent backward, at nearly right angles to the clypeus, with the mandibles closed over it, so that it is not accessible for study. For this reason, it has not seemed advisable to use it for analytical purposes.

MOUTH PARTS.

None of the mouth parts seem to be useful for the determination of the species and their description therefore is not included here. I might say, however, that possibly the mandibles, labial palpi, and maxillary palpi would be of use in the determination as in most of the insects examined, the palpi show to the full extent. Maxillary palpi five jointed, labial palpi four jointed.

The mandibles are somewhat curved, having two teeth, which are blackish to their bases. When the jaws are closed they overlap.

ANTENNÆ.

The antennæ are long. The basal portion of the bulb of the proximal segment or scape is rather small and articulates with the head in a socket. Its diameter, at this end, is about equal to its length to where it unites with the enlarged portion of the scape, but it is somewhat narrower toward the place where it enlarges into the scape proper. The bulb appears to be an entire segment, but this is not the generally accepted view. The scape which is the stoutest segment of the antennæ is somewhat smaller at its base, gradually increasing to the base of the next segment, the pedicel. This seems to extend down into the scape for some little distance. There is also a third segment before we come to the filament proper which is nearly twice as broad as long, and is called the ring joint. This seems to be rather unusual. The filament which consists of about fifty-four segments has those near the base a little longer than the others, gradually decreasing in length as we go towards its extremity.

THORAX.

The thorax in general is strongly compressed laterally, very finely pubescent, and is of a yellowish russet color.

PROTHORAX.

The prothorax, as seen from the side, is triangular in outline, marked by fine, distinct, oblique, transverse striations which are most noticeable near the lower anterior portion of the plate, while viewed from above it is a very narrow transverse band. Its anterior margin is straight and elevated, forming a flange, which projects slightly forward. Looking down from above, there can be easily detected with the aid of a microscope, a semicircular indentation or groove, which leads to the query, "Was this portion once a distinct plate representing a much reduced pronotum while the large triangular plate at the sides represented a much enlarged pro-pleuron?" It is set out very prominently from the mesethoracic plates by quite conspicuous sutures. The facial portion of the prothorax, lying just behind the head (episternum?) is somewhat hoof-shaped having a deeply impressed line extending from the point where the head joins the prothorax to a point near the insertion of the fore coxa, thus dividing it into right and left halves.

MESOTHORAX.

The mesonotum is a broad plate distinctly convex, lying between the fore-wings and extending forward to the dorsal portion of the prothorax. Starting near the anterior margin and at equal distances from the middle of the plates, are two lateral grooves known as the parapsidal furrows which curve slightly inward and extend nearly to the scutellum. These grooves become weak posteriorly, being only slightly noticeable after they have passed the middle of the plate. The anterior margin of this plate is bent slightly upward or reflexed, and this is continued around the sides as far back as the tegula, where it leaves the margin and becomes a distinct ridge which passes obliquely backward across the plate.

Directly behind the mesonotum already described, is the scutellum, the median portion of which is trapezoidal in outline, longer than broad, the longer base anterior, the shorter base being posterior and slightly over half the length of the former. Between the mesonotum and median portion of the scutellum

is a deep trough-like depression, whose ends are closed by a continuation backward onto the scutellum of the ridges, spoken of previously, which may be designated as the dorso-lateral ridges. On the mesonotum, just in front of the trough and branching off from the dorso-lateral ridge is a short oblique ridge which extends outward and forward to the insertion of the fore-wing. The sides of the trapezoid are continuations backward of the dorsal-lateral ridges. Near the rear margin of the scutellum these become lost. Along this margin there is a reflexed edge or flange which extends obliquely towards the insertion of the fore-wings.

The surface of the lateral portions of the scutellum lies at a sharp angle with that of the median portion (trapezoidal) and extends from the dorsal lateral ridge downward and forward to the base of the forewing. As already stated the hinder margin of this portion is reflexed nearly to the wing attachment. The mesothoracic pleuron is a large plate which lies below the wings, its posterior margin being approximately indicated by an oblique groove extending downward and backward from beneath the fore-wing to just beneath the hind wing where it bends a little more downward, and takes a nearly straight path to the meso-coxa. From here it passes forward, curving somewhat until about opposite the base of the fore coxa. It then turns sharply upward, and passing by the base of the fore-coxa follows along the edge of the prothorax to the base of the fore-wing.

There are several ridges and grooves on this plate, but nothing which can be termed a distinct suture, that is, dividing the pleuron into subordinate plates. The meso-coxa is attached near the extreme posterior edge of this plate, occupying about one-third of its width, which is somewhat greater ventrally than dorsally.

METATHORAX.

Just to the rear of the scutellum and below it is a narrow plate which extends from one hind wing to the other and is known as the post scutellum. The rear margin of this plate is reflexed as in the case of the rear margin of the scutellum, and extends forward nearly to the base of the hind wings.

The part of the metapleuron nearest the hind wing (episternum) is triangular in outline. The apex of the triangle extends ventrally and comes to a point just between the meso-

thoracic pleuron, and the metathoracic epimeron, while the base of the triangle lies dorsally below the furrow of the post scutellum.

The metathoracic epimeron is a large plate bordered on its dorsal side by the median segment, anteriorly by the metathoracic episternum above, and the mesothoracic pleuron below, while posteriorly it bears the coxa of the hind leg.

The median segment is a large arched plate distinctly striate above covering the area between the post scutellum, in front, and the petiole behind, and extending transversely from the metathoracic pleuron of one side to that of the other. A short distance behind the angle where the median segment, epimeron and episternum of the metathorax meet is an oval stigma on each side. Near the hinder margin of the plate, on each side, is a crescentic elevation, immediately behind which is a depression of the surface. Extending forward from this crescent to a point near which the median segment meets, the posterior dorsal angle of the metathoracic episternum is an elevated area, just below which is situated the dorsal edge of the stigma. This elevated area may be used for convenience as indicating the division between the dorsum and the sides of the median segment, though there is no evidence of a separation of these portions into separate plates.

At the extreme posterior end of the median segment there is a semi-circular carina which is quite prominent. The median segment is marked by fine, distinct, transverse striations and the metathorax, as a whole, is pubescent, and very finely punctured.

ABDOMEN.

This portion of the body has more or less of a russet brown color varying from a light yellowish brown, in some specimens, to a reddish brown, in others. The abdomen is composed of eight segments in both male and female, and is compressed laterally, more so ventrally than dorsally. The segments, as a general thing, decrease somewhat in length after the second one which is only about half as long as the first, but rapidly increasing in height up to the sixth inclusive, but the seventh and eighth are smaller.

The median segment has been included with the description of the metathorax. While it is undoubtedly the first segment of the abdomen, for convenience of description, we may consider

the segment, behind the thoracic mass, as a whole, as being the first segment. The first segment of the abdomen, counted in this way, is attached at the ventral side of the posterior end of the median segment. It is straight and nearly twice as long as the second segment. Just above its attachment to the median segment and below the dorsal portion of the posterior carina is a small but prominent muscle or funiculus, which is attached to the anterior dorsal portion of the ventral plate. A little in front of the middle of the segment, on each side, is an oval stigma, and situated about two-thirds the distance from the stigma to the posterior end of the thorax is an elliptical opening which, in some cases, apparently extends clear through the segment from side to side. On closer examination one will readily detect a thin membrane, stretched across this opening about in the middle of the body, separating it completely into right and left halves.

This opening is formed where the dorsal plate bends upward, and apparently leaves the ventral plate, only the thin membrane, already referred to, forming a connection between the two. It then turns downward and becomes closely connected with the ventral plate, again extending as narrow bands along the upper margins of the same plate nearly to the median segment. Viewed from above, the dorsal plate appears to divide just behind the funiculus, and extends as arms to the median segment, forming the lateral portions already described.

The ventral plate of the sixth segment is most prominent. From this portion of the sixth segment is protruded the ovipositor, and its palpi or feelers, which are hairy, except their basal portions which are concealed by the remaining segments. The ovipositor and feelers extend quite a distance beyond the extremity of the abdomen. On the eighth segment, a pair of cerci are situated at its extreme posterior margin, and approximately half way between the ventral and dorsal portions of this plate.

In the female the stigmata of the second and third segments are well in front of the middle, while the remainder are closer to the anterior margin, and none are perceptible on the last two segments. In the male the stigmata approach the anterior margins of the segments more and more passing backward, but they do not come close to it. On the seventh and eighth they appear to be absent.

The genitalia of the male protrude prominently between and beyond the last dorsal and ventral plates of the abdomen. The last segment in the males being noticeably shorter than the others, while in the females the last two are noticeably shorter.

All of the ventral segments of the abdomen are rather soft and membranous. The claspers are large and broad.

WINGS.

The wings are quite large and colorless, with the exception of a yellowish tinge, produced by the presence of reddish brown nerves and numerous short hairs, generally distributed over both the upper and under surfaces. Cresson's nomenclature of wings is the one used in this paper.

FORE WING.

Separating the marginal, or radial cell, from the median, or externo-medial cell, is a well-developed stigma, which is long, narrow and yellowish brown in color. It is considerably wider beyond its middle than before. The marginal or radial cell is lanceolate. The greater part of its anterior and longer side is formed by the costa and its remaining basal portion by the stigma. Posteriorly it is separated from the disco-cubital cell by the first abscessa of the radial nervure which runs from the stigma to the apex of the small triangular areolet. It is separated from the third submarginal cell by the second abscessa of the radial nervure, which is longer than the first, and is quite strongly bent at its origin where it forms approximately a right angle with the radial nervure. The median cell which is one of the largest of the wings is about four times as long as its greatest width. This latter dimension, occurring about three-fourths of the distance from the base of the wing to the outer end of the cell. It is separated from the sub-median cell posteriorly by the externo medial nervure and from the disco-cubital beyond by the basal nervure. The third side is formed by the costal and sub-costal nervures fused.

The costal cell is absent due to the fusing of the costal and sub-costal nervures, the sub-costal portion being however, more prominent than the costal. The disco-cubital cell which is probably the largest cell of the wing is irregular in outline, is bounded by five different nervures, namely, first abscessa of the radial, first transverse cubital, disco-cubital, discoidal and basal nervures, and a portion of the stigma.

Of the above, not mentioned before, the first transverse cubital separates this cell from the areolet. The disco-cubital nervure which separates it from the third discoidal cell has quite a prominent stump of a vein near its middle known as an abbreviated cubital nervure which extends into the cell. About halfway from this stump, to the triangular areolet is a short bulla. This cell is separated from the second discoidal cell by the discoidal nervure and receives but one recurrent nervure at the point where the disco-cubital and discoidal nervures meet. There is but one completely enclosed sub-marginal cell which is regarded as the second or areolet. It is small, approximately triangular and in all the specimens I have examined, the second transverse cubital nervure which separates this cell from the third sub-marginal cell has a bulla extending half way from the base to the apex of the triangle, beyond which the vein bends slightly, taking a straight line to the apex of the triangle.

The third sub-marginal cell is separated posteriorly from the second apical cell by the cubital nervure, and extends to the margin of the wing. Its other bounding lines have already been described. Submedian or internomedial cell is quite long and narrow, the externo-medial nervure separating it from the median in front, and the first abscessa of the anal nervure from the anal cell behind. Outwardly it is separated from the second discoidal cell by the transverse medial nervure which joins the externo-medial nervure just beyond the origin of the basal nervure, thus making it post fercal. The second discoidal cell is separated posteriorly from the anal cell by the second abscessa of the anal nervure which is about one-half the length of the first abscessa. Outwardly it is separated from the third discoidal cell anteriorly and first apical cell posteriorly by the first recurrent nervure, that portion of this nervure however separating it from the former is much shorter than the latter. The first recurrent nervure has a small bulla patch where it joins the margin of the wing. The third discoidal cell is separated posteriorly from the first apical cell by the first abscessa of the subdiscoidal nervure and outwardly from the second apical cell by the second recurrent nervure, at the center of which is a distinct bulla patch, while at its anterior extremity just below the areolet is another small bulla. The second apical cell is separated posteriorly from the first apical cell by the second abscessa of the sub-discoidal nervure which is much

shorter than the first abscessa, and extends to the margin of the wing. The anal cell is the longest cell of the wing. It is bounded, anteriorly, by the anal nervure and, posteriorly, by the margin of the wing which has a small fold near the extremity of the cell (frenal fold.) This cell extends to a point slightly beyond the outer end of the second discoidal cell. The first apical cell has already been described with the exception of mentioning that its posterior and outward boundary is formed by the margin of the wing.

HIND WING.

The costal cell is quite long extending somewhat over half the entire length of the wing, and it is, by far, the narrowest cell. It is separated, posteriorly, from the median cell, by the subcostal nervure. Anteriorly it is bordered by the costal nervure which extends somewhat less than half the length of the cell, and by the margin of the wing, which is a continuation of the latter. The marginal or radial cell is separated posteriorly from the median cell by the first abscessa of the marginal or radial nervure, and from the submarginal or cubital cell by the second abscessa of the same nervure. Its anterior and outward boundary is formed by the margin of the wing.

Six frenal hooks are found near the middle of the anterior margin of this cell. Submarginal or cubital cell is separated posteriorly from the discoidal cell by the second abscessa of the cubital nervure, inwardly from the median cell by the transverse cubital nervure, and extends outward to the margin of the wing. The median cell is the longest and largest cell of the wing. It is separated posteriorly from the submedian cell by the externo medial nervure and from the discoidal by the first abscessa of the cubital nervure. The submedian cell is separated posteriorly from the anal cell by the anal nervure and from the second discoidal cell by the first abscessa of the transverse medial nervure which is somewhat longer than the second abscessa, and forms with it approximately a right angle. Outwardly it is separated from the first discoidal cell by the second abscessa of the transverse medial nervure. The discoidal cell is separated posteriorly from the second discoidal by the discoidal nervure, and extends to the margin of the wing. Second discoidal cell is separated posteriorly and inwardly from the anal cell by the second abscessa of the anal nervure and extends to the margin of the wing.

TEGULÆ.

The tegula is a small chitinous plate, more or less triangular, with rounded corners, lying over the base of the fore wing. It is slightly sericeous, and to some degree arched.

LEGS.

The legs are quite long, rather slender, hairy, and all these segments beyond the femora are armed with spines to a greater or less degree. Coxa more or less bulb shaped. The two trochanters taken together are as long or a little longer than the coxa, and they are of about equal length in the hind leg, while in the middle and fore legs the outer segment is only about half the length of the other. Femur is second in length to the tibia, the longest segment, and in stoutness to the coxa which is the stoutest segment. The tibia is largest at its distal end. It is armed with spines above, below, and on the sides, these showing a partial arrangement into longitudinal rows. At its outer end where it joins the first tarsal segment is a circlet of spines, two of which are much longer and stouter than the others in the posterior and middle legs, which are called tibial spurs. The inner spur is nearly twice as long as the outer one. These spines are clothed with hairs. The fore leg instead of bearing two tibial spurs has one long spur-like appendage nearly half as long as the segment, curved for about one-third of its length from the base to the extremity, bearing hairs on its inner surface which in connection with a corresponding modification at the base of the first tarsal segment acts as a cleaning apparatus.

There are five tarsal segments. The first is by far the longest, being about twice as long as the second, and three times as long as the third which is about as long as the fourth and fifth taken together. The fourth segment is slightly shorter than the fifth. The first three segments are armed with spines beneath, on the sides and at their outer ends. The fourth segment is the shortest tarsal segment, and is provided with spines at its end where it joins the base of the fifth and last segment. The fifth segment is not armed with spines except for a few long spine-like hairs at its extremity where the pair of well developed claws and a pulvillus between them occur. On the under side of the claw are borne about twenty teeth.

SEXUAL DISTINCTIONS.

Aside from the presence of a sting in the females and of more or less copulatory organs in the male, other differences may be noticed in the sexes. Ocelli seem to be closer together in the male, and also to the compound eyes than in the females. The male has fifty-seven segments in the antennæ, and the female fifty-eight, but it would seem probable, considering the large number of segments that this might vary somewhat.

TABLE OF GENERA.

Terminal teeth of mandibles longer than the inner; cheeks and temples not broad; scutellum more or less margined laterally; transverse median nervure distinctly postfurcal to the origin of the basal nervure.....PANISCUS Gravenhorst.

Teeth of mandibles equal in length; cheeks and temples broad; scutellum not margined laterally; transverse medial nervure interstitual with the origin of the basal nervure, rarely slightly postfurcal..................OPHELTES Holmgren.

DESCRIPTION OF SPECIES.

Opheltes glaucopterus (Linn). Description taken from Provancher.

Faune Entomologique Du Canada, II, 1883, p. 359.

Female—Length, 68 inch. Black variegated with red. Head varied with russet, except a black spot covering all the vertex and the back side of the head. Antennae russet, brown at the extremity, almost as long as the body. Thorax black; scales clear, a line before and another below, two lines on the back of the mesothorax, and its exterior borders, also sometimes the scutellum, all the legs with trochanters, the abdomen except the last three segments, of a yellowish russet color. Wings with the costa and the stigma yellow, the nervures brown; areola small, not petiolated, subtriangular; median nervure not appendiculate, arched. Metathorax bearing a little elevated canal in the middle, and a carinae on each side with another transversal at the apex, these carinaes being elevated in the form of acute tubicles in certain spots. Hind part (hind coxae) russet black at the base.

Paniscus alaskensis, Ashm.

Proceedings of the Washington Academy of Sciences, IV, 1902, pp. 237-8.

Male—Length 10 mm. Head yellow, with purplish-brown eyes, and very much as in PANISCUS GEMINATUS Say, except that the ocelli are not placed on a black spot, and the lateral ocelli do not quite touch the eye margin, as in that species. The thorax and abdomen are pale honey-yellow; a stripe on sides of prosternum, the lateral margins of the mesonotum, and a stripe on the parapsidal furrows behind, are yellowish-white; the apical transverse carina is indicated only laterally, being wholly obliterated medially, the surface of the metanotum before it being very finely, transversely aciculate, behind it polished and impunctate. Wings hyaline, the venation as in P. GEMINATUS, the costal vein and the stigma yellow, the subcostal vein and the internal veins being brown or brown black. External claspers similar to those in P. GEMINATUS but slightly narrower.

Type—Cat. No. 5688, U. S. Nat. Museum. From Kukak Bay, July 4. Five specimens.

Paniscus albotarsatus Prov.

Faune Entomologique Du Canada, II, 1883, p. 361.

Male—Length .40 inch. Beautiful yellow, face of a yellowish white, the ocelli black, contiguous with each other. Posterior tarsi white except at the base of the first segment; their claws (hooks) brown. Abdomen elongated, compressed; slightly arched, slim, scarcely tinged with brown at its extremity. Wings colorless, nerves brown; stigma yellow. Median nervure arched, without a rudiment of a nervure at its middle; areola subtriangular, very oblique, very small. G.

The color almost uniform, color of the species with its posterior tarsi which distinguishes it at first sight. In the female the abdomen is a little obscure towards the extremity, the ovipositor longer than the length of the abdomen.

Paniscus albovarigatus, Prov.

Faune Entomologique Du Canada, II. 1883, p. 361.

Female—Length .38 inch. Uniform, honey-yellow; the face below and above the antennae, the orbites all around the eyes, a line on the edges of the mesothorax prolonged to the tip of the scutellum, two lines upon the back of the mesothorax, a line below the anterior wings, a large spot lower upon the flanks (sides) with another smaller one below the posterior wings, of a beautiful white. Ocelli not touching the eyes, and also distant from each other. Metathorax uniform (simple, even) obscurely transversely aciculate; areola of wings small, triangular, pedunculated, slightly oblique, abdomen convex, compressed from the third segment, brownish in its posterior half. AC.

Paniscus geminatus (Say).

Faune Entomologique Du Canada, II, 1883, p. 360.

Female—Length .65 inch with a uniform yellowish russet tinge. Face a little clearer; ocelli contiguous with the eyes, and also with each other. Wings colorless, nerves black, stigma yellow. Median nervure strongly arched, with a rudiment of a nervure very apparent towards its middle. Metathorax pubescent, very finely punctured. Legs and posterior tarsi a little darker than the rest. Abdomen compressed, slightly convex, brownish at the extremity; ovipositor longer than the length of the abdomen. AC.

Paniscus medius, Ashm.

Proceediings of the California Academy of Sciences, IV, 1894, p. 128.

Female—Length 12 mm.; ovip. 2 mm. Brownish-yellow; face and clypeus yellowish white; ocelli large, prominent, the lateral touching the eye; eyes distinctly emarginate within; thorax smooth, trilobed; metanotum smooth, without a vestige of carinae; wings hyaline, the costa and stigma brownish-yellow, the other nervures black, the discoidal nervure with a distinct stump of a vein; abdomen twice as long as the head and thorax united, strongly compressed, viewed from the side,

not much broadened towards apex; the petiole is a little more than one-third longer than the second segment, with the spiracles placed at two-fifths its length, the second segment is about two and one-half times as long as wide at apex.

Described from one specimen, from San Esteban (Haines).

This species resembles somewhat P. texanus, but is larger, differently colored, with a stump of a vein in the discoidal nervure, and with the segments of the abdomen relatively different.

Paniscus melanostigma, Cam.

Biologia Centrali Americana; Hymenoptera, I, 1886, p. 303.

Rufo-testaceous, mesonoto nigro; capite flavo; flagello antennarum fusco; alis hyalinis, stagmate nigro. Female.

Long. 15 millim.

Hab. Panama, Volcan de Chiriqui (Champion).

Face closely punctured; metathorax closely transversely striated. Areolet moderately large, straight, the recurrent nervure received a little beyond the middle; there is no branch on the cubital nervure.

Easily known from its allies by the black stigma and nervures. The petiole is longer compared to the second segment (the relative length of the two being as in *P. geminatus*) than in *P. tinctipennis*.

Paniscus nigripectus, Ashm.

Proceedimgs of the United States National Museum, XII, 1889, p. 425.

Female—Length 16 mm. This species is much more closely allied to P. geminatus than is P. texanus, and structurally it is almost identical, but the mesonotum, mesopectus, stigma, and veins are black; the lateral ocelli touch the eye; the stump of the vein at the middle of the cubitus is wanting, and the submedian cell is only one-third the length of the transverse median nervure longer than the median cell; the second abdominal segment is two-thirds the length of the petiole, the spiracles situated at about one-third its length.

Habitat.—Texas.

Described from one specimen in Belfrage Collection.

Paniscus ocellatus, Vk.

Proceedings Entomological Society of Washington, Vol. XI, 1909, p. 211.

Female—16 mm.; tegument pale castaneous to castaneous, orbital margin yellowish, tips of mandibles and edge of ocelli more or less blackish; wings faintly cloudy, transparent, stigma and costa pale, translucent, other veins mostly brownish or almost black; anterior ocellus elliptical, transverse, the shortest distance between the anterior ocellus and the nearest point on the eye; antennae 59-jointed, cylindrical, the joints well defined, the fifth to penultimate subequal and longer than wide at base, the apical joint rounded, subconical, a little longer

than the penultimate; discocubital vein with a trace of a stump, recurrent vein interstitial with the second transverse cubitus, aerolet quadrangular, metathorax transversely wrinkled above and with a parenthesis-shaped carina on each side; abdomen shining and with a bloom-like pubescence that is conspicuous only in certain lights, the rest of the body very similarly pubescent, the pubescence pale, seemingly tinged with golden.

Male—Very like the female, but with a yellow face and 56-jointed antennae; male paratopotype with a distinct stump of a vein.

Type.—Female and male and paratopotype, No. 12320, U. S. National Museum.

Type locality.—Wellington, Kans., E. G. Kelley, collector, Webster, No. 5431, U. S. Department of Agriculture, Bureau of Entomology.

Paniscus subfuscus, Cress.

Proceedings of the Entomological Society of Philadelphia, IV, 1865, p. 57.

Dull rufo-fuscous, legs and antennae paler; basal segments of abdomen piceous; wings hyaline.

Female—Dull rufo-fuscous, opaque; clypeus pale, pubescent; antennae as long as the body, slender, dull fulvous, slightly dusky at tips. Thorax with the dorsal lines deeply impressed; scutellum prominent, carinated on each side; metathorax minutely sculptured, incised at base, with a small acute tubercle on each side behind. Wings hyaline; nervures fuscous, stigma testaceous; areolet small, subpetiolated, oblique. Legs pale fuscous, the femora slightly dusky. Abdomen stout, arcuated, subcompressed, clothed with a very short, appressed, pale pubescence; 1st segment elongate, slightly broader at tip, with a faint tubercle on each side before the middle; 2nd segment about one-third shorter than the 1st; the three basal segments above, except the extreme base of the 1st, stained with piceous; apical margins of the remaining segments pale; ovipositor about as long as the 1st segment of the abdomen. Length 9 lines; expanse of wings 15 lines.

Collection.—Ent. Soc. Philad. One specimen.

This does not agree with the description of P. Rufus Brulle, which I have not seen, and which is said to inhabit Cuba.

Paniscus texanus, Ashm.

Proceedings of the United States National Museum, XII, 1889, p. 425.

Female—Length 9 mm. This species has probably been confused in our collections with P. geminatus Say; but besides its much smaller size it can be readily separated by the following differences:

The third joint of the antennae is only slightly longer than the fourth; the mesonotum is smooth without parapsidal grooves; the lateral keels of the scutellum become delicate posteriorly; the spiracles of the petiole are placed just anterior to the middle; the second abdominal segment viewed from above is trapezoidal but slightly longer than wide

and only half the length of the petiole; the basal joint of hind tarsi only twice the length of the second; the submedian cell is as long or slightly longer than the median cell, the length of the transverse median nervure; while whereas, in p. geminatus there is always a distinct stump of a vein at the middle of the cubitus, in P. texanus it is entirely wanting or only the base remains.

Habitat.—Texas.

Described from one specimen in Belfrage Collection.

Paniscus tinctipennis, Cam.

Biologia Centrali Americana; Hymenoptera, I, 1886, p. 303.

Fuscous, testaceo variegatus; capite flave; pedibus pallide testaceis, coxix posterioribus femoribusque posticis fuscis; alis fumatis, stigmate testaceo. Female, Long. 15 millim.

Hab. Panama. Volcan de Chiriqui 2000 to 3000 feet (Champion).

Antennae a little longer than the body, microscopically pilose; the flagellum dark fuscous, the scape testaceous. Head yellow, the occiput dark fuscous; the ocellar region black; the face obscurely punctured, projecting in the middle; mandibles testaceous, the tips black; palpi yellow. Thorax dark fuscous; a line on the pronotum, the sutures of the mesonotum, a mark below the tegulae, the sides of the scutellum, and the lower part of the metapleura, pale testaceous. Metathorax closely transversely striated. Abdomen fuscous, the base of the first three segments and their ventral surface pale testaceous. Wings with a fuscous tinge; areolet minute, not oblique; the recurrent nervure interstitial.

Differs from *P. geminatus* in the fuscous colour of the body in the wings having a decided smoky tinge, in the expansions on each side of the metathorax being much more distinct, in the abdomen being broader and not so compressed, and in the petiole being thicker and shorter compared to the second segment.

Index to Notes of Interest on Paniscus Not Included in This Paper.

1. Nuttal: Insects and Disease, p. 41, 1899.
2. Packard: Text book of Entomology, p. 517.
3. Proceedings of the Entomological Society of Washington, IV, pp. 45-47.
4. The Canadian Entomologist, XIX, p. 80.

INDEX TO LETTERING PLATES.

a, anal cell.
a_1, a_2, anal nervure (First and Second abscissas).
ab, abdomen.
ac, abbreviated cubital nervure.
ap, first apical cell.
ap_1, second apical cell.
aw, anterior wing.
b, bulb.
bn, basal nervure.
c, costal nervure.
c_1, costal cell.
cc, cerci.
cf, clypeal foveae.
cl, clypeus.
cla, claspers.
c + sc, costal and subcostal nervures blended.
cu, cubital or submarginal cell.
cu_1, cu_2, cubital nervure (First and Second abscissas).
cu_3, cubital nervure.
cx, coxa.
d, discoidal nervure.
d_1, discoidal cell.
d_2, second discoidal cell.
d_3, third discoidal cell
dc, disco-cubital nervure.
dc_1, disco-cubital cell.
e, eye.
em, externo-medial nervure.
em_1, externo-medial or median cell.
ep, triangular plate, Epimeron?
epm, metathoracic epimeron.
eps, metathoracic episternum.
eps_1, hoof-shaped plate, Episternum?
f, funiculus.
ff, frenal fold.
im, interno-medial or submedian cell.
m, marginal or radial cell.
m_1, m_2, marginal or radial nervure. (First and Second abscissas).
mc, median cell.
md, mandible.
mn, mesonotum.
mp, mesothoracic pleuron.
ms, median segment.
o, ovipositor.
oc, ocellus.
p, parapsides.
ped, pedicle.
pn, pronotum.
po, palpi of the ovipositor with tactile hairs.
psct, postscutellum.
pt, antennal pit.
pw, posterior wing.
r, ring joint.
rc_1, first recurrent nervure.
rc_2, second recurrent nervure.
s, spiracle of median segment.
sc, subcostal nervure.
sd_1 sd_2, subdiscoidal nervure (First and Second abscissas).
scp, scape.

sct, scutellum.
sm, submedian cell.
sm_2, second submarginal cell or areolet.
sm_3, third submarginal cell.
sp, spiracle of abdomen.
st, stigma.
t, tegula.
tc, transverse cubital nervure.
tc_1, first transverse cubital nervure.
tc_2, second transverse cubital nervure.
tm, transverse medial nervure.
tm, tm_2, transverse medial nervure (First and Second abscissas).

EXPLANATION OF PLATES.

The following figures were drawn with the Camera Lucida.

PLATE XXIV.

FIG. 1. Dorsal view of the thorax of Paniscus geminatus.
FIG. 2. Side view of the thorax of Paniscus geminatus.
FIG. 3. Anterior tibial comb of Opheltes glaucopterus.
FIG. 4. Anterior tibial comb of Paniscus geminatus.
FIG. 5. Side view of the anterior end of the first segment of the abdomen of Paniscus geminatus.
FIG. 6. Dorsal view of the anterior end of the first segment of the abdomen of Paniscus geminatus.

PLATE XXV.

FIG. 7. Anterior wing of Paniscus geminatus.
FIG. 8. Posterior wing of Paniscus geminatus.
FIG. 9. Anterior wing of Opheltes glaucopterus.
FIG. 10. Posterior wing of Opheltes glaucopterus.

PLATE XXVI.

FIG. 11. Posterior leg of Paniscus geminatus.
FIG. 12. Clypeus and labrum of Paniscus geminatus.
FIG. 13. Mandible of Opheltes glaucopterus.
FIG. 14. Mandible of Paniscus geminatus.

PLATE XXVII.

FIG. 15. Front view of the head of Paniscus geminatus.
FIG. 16. Side view of the head of Paniscus geminatus.
FIG. 17. Maxillae and labium of Paniscus geminatus.

PLATE XXVIII.

FIG. 18. Abdomen of Paniscus geminatus (female).
FIG. 19. Abdomen of Paniscus geminatus (male).
FIG. 20. Basal joints of the antenna of Paniscus geminatus.
FIG. 21. Claw of Opheltes glaucopterus.
FIG. 22. Claw of Paniscus geminatus.

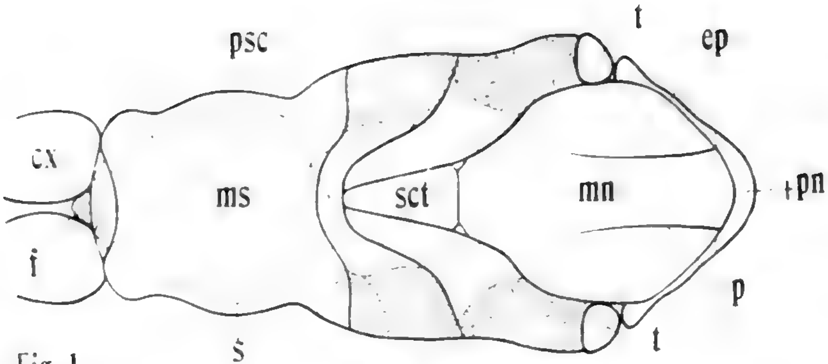

Fig. 1

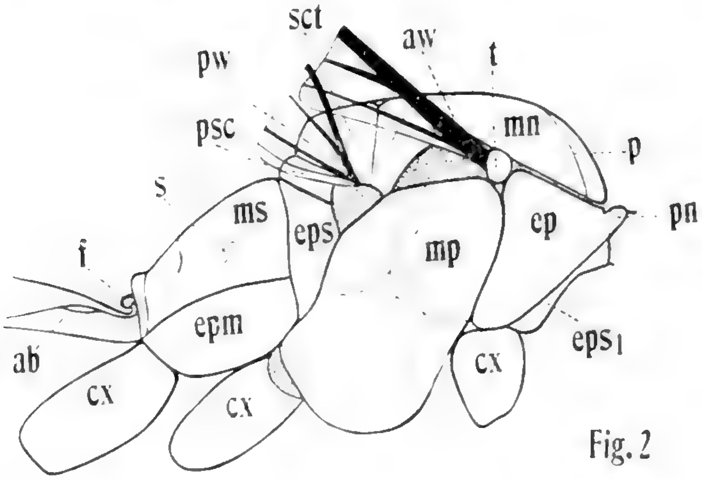

Fig. 2

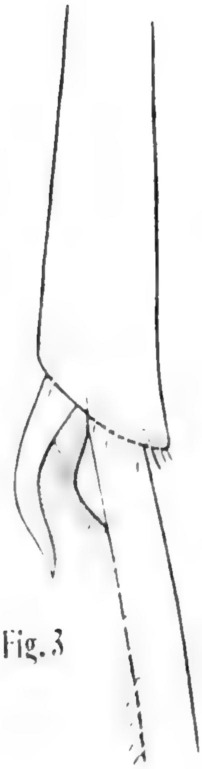

Fig. 3

Fig. 4

Fig. 5

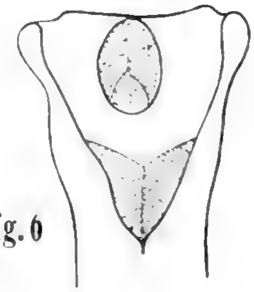

Fig. 6

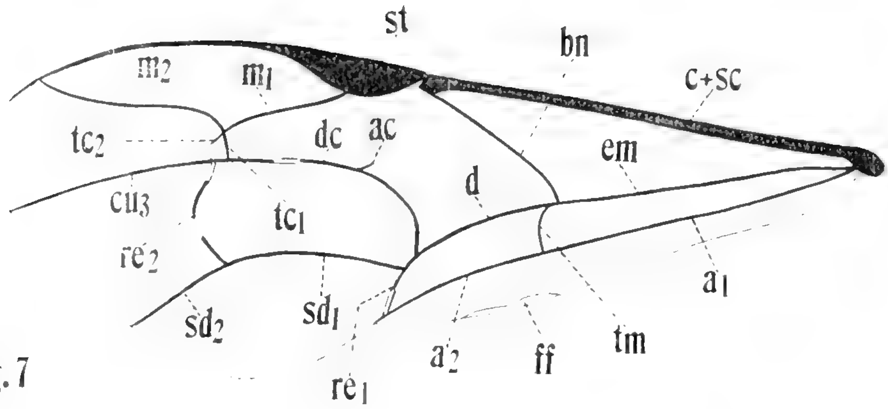

Fig. 7

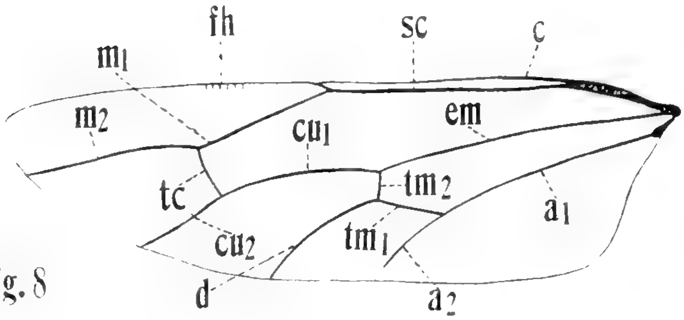

Fig. 8

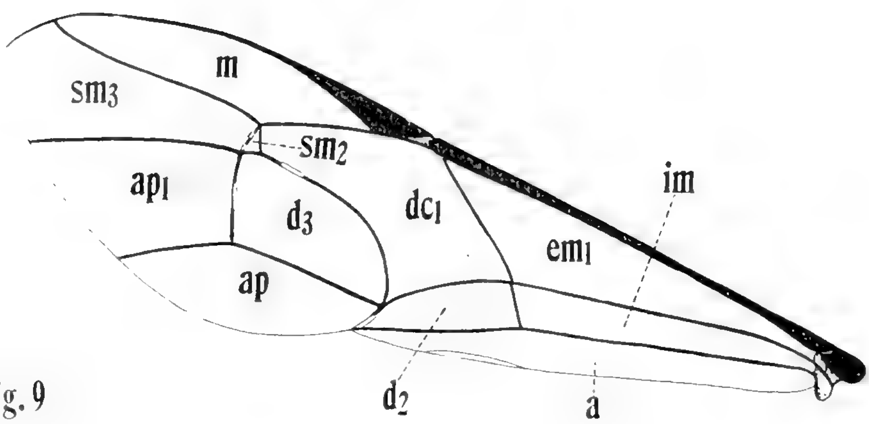

Fig. 9

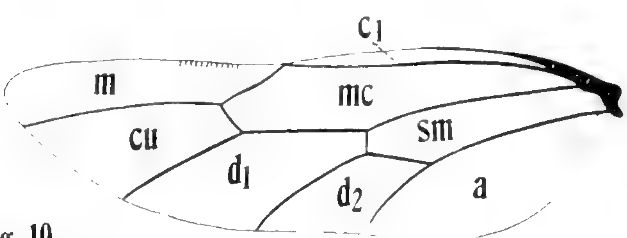

Fig. 10

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Fig. 11

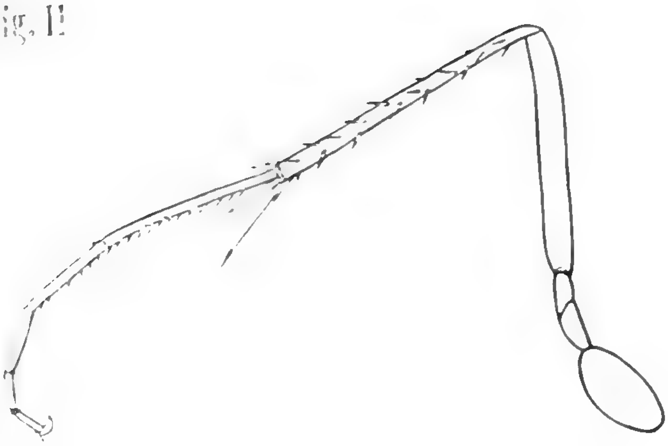

Fig. 12

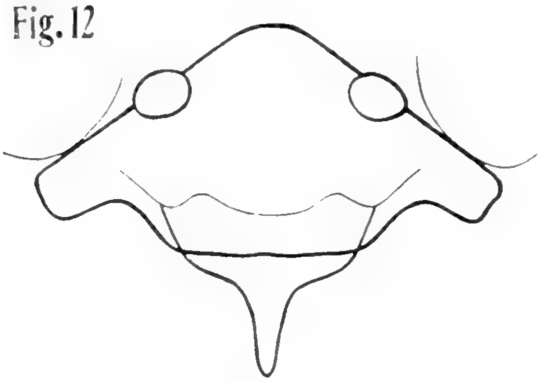

Fig. 13

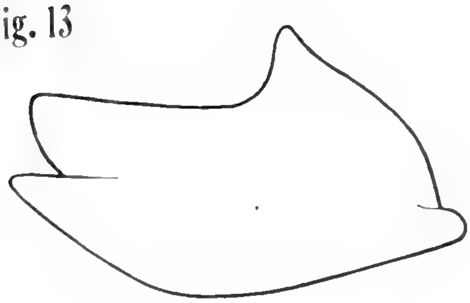

Fig. 14

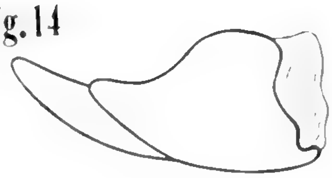

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Fig. 15

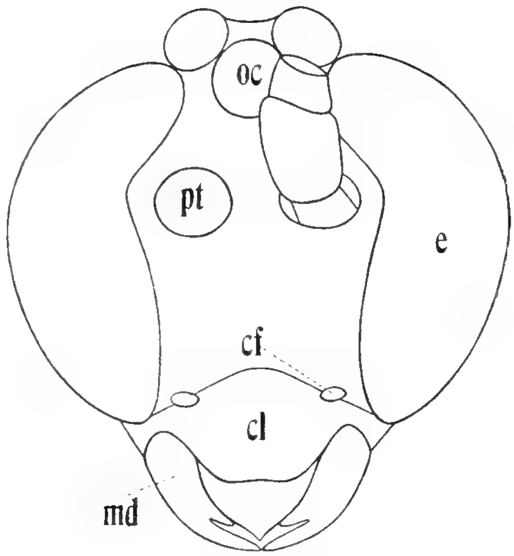

Fig. 16

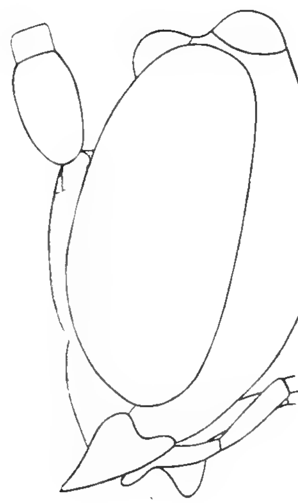

Fig. 17

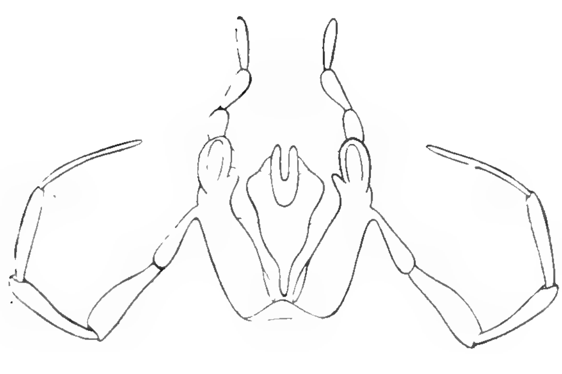

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Fig. 18

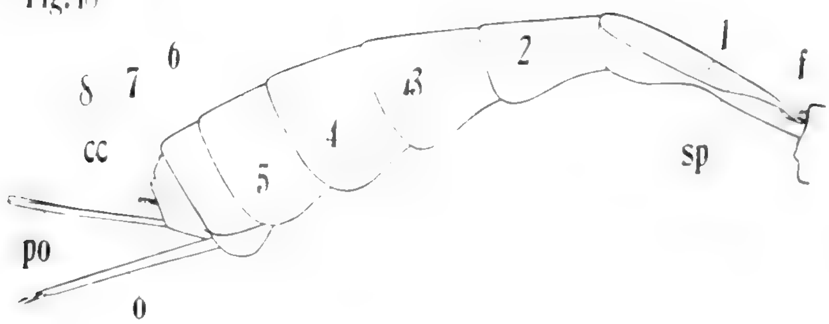


Fig. 19

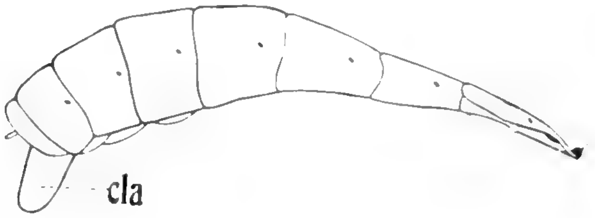


Fig. 20

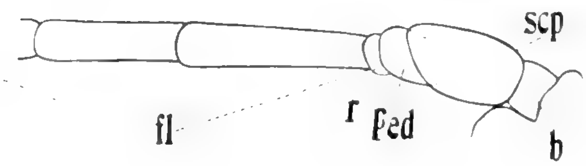


Fig. 21

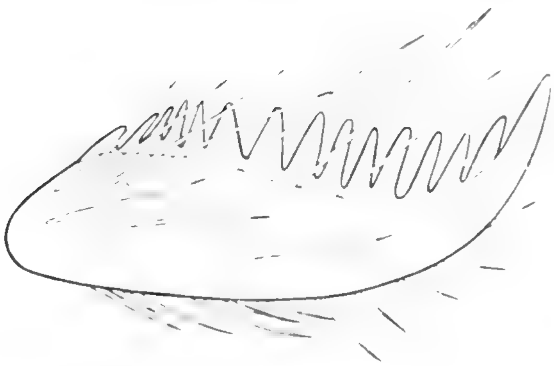
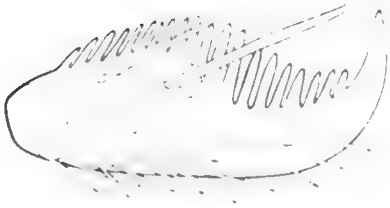


Fig. 22



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THE REDISCOVERY OF A PECULIAR GENUS AND SPECIES OF ORIBATIDAE.

By H. E. Ewing,
Ames, Iowa.

Years ago Mr. Theo. Pergande made a drawing of a very peculiar species of the order Acarina. The specimens of this species were collected by Mr. E. W. Allis, at Adrian, Mich., in October, 1885. This acarid, with many others, it appears, was found in connection with a study of the eggs and larvæ of the 17-year locust. Some time later when Mr. C. L. Marlatt was ready to publish his bulletin upon the 17-year locust, he asked Mr. Nathan Banks to determine the Acarina for him. Mr. Banks looked over the mite figures (these were very accurately drawn, and represented beautifully the characters of the different species), and named what he could. It was Mr. Banks' intention to describe these species when he had examined the specimens. Later he did describe some of them, but the slide of this species he could not find!

Notwithstanding the fact that this slide was never found, the figure and name of this interesting species were published in Mr. Banks' treatise on the Acarina.* Whether or not Mr. Banks thought at the time his paper was published, that this genus was good, it is hard to tell. No comment whatever, is made upon this genus or species, and in his key to the genera of the *Oribatidæ* given on the opposite page from the picture, this genus is omitted.

While looking over some slides in the cabinet of the Department of Zoology, Iowa State College, I came across a slide of this species which had the following data upon it: "*In galls on elm twigs. Ames, Iowa, April 16, 1894.*" The slide contained about a dozen individuals well preserved but poorly mounted. I dissolved off the cover-glass and obtained the specimens without injury for my work upon the species. I found that this species represents in almost exact detail all the peculiar characters shown in Mr. Pergande's figure just referred to. These characters are given in the following pages.

*A Treatise on the Acarina, or Mites. Proc. U. S. Nat. Mus., Vol. XXVIII, p. 70, Fig. 136.

Now in regard to the question of who is to be given credit for the genus *Oripoda* for which this species stands as a type. Mr. Banks writes that he never has seen any of the individuals of this species, and that the species never has been described. Mr. Pergande was not a special student of the Acarina, and did not give a name to the species. While the author himself is the only one who has ever actually studied specimens of this species with the idea of finding out the systematic value of their characters, yet I am not responsible for the name or figure in any way. In the International Code, I can find nothing which states that the person who first describes, or in any way makes recognizable a new species or genus, must have actually seen the species he is naming or describing. Morally it does not appear proper to describe species upon secondhand information, still, some of the greatest advances in science are made in the interpretation of facts observed by others. Under these conditions, it appears to me that to give both Mr. Banks and Mr. Pergande credit for the genus and species is the best way out of the difficulty: in reality the conditions are very similar to a joint authorship.

The genus *Oripoda* I count as a very distinct and peculiar genus. The form and shape of the cephalothorax are entirely different from that of any other species of the *Oribatidae;* the queer shapes and forms of the segments of the second pair of legs represent a great exaggeration of the variations from the common type, as is shown in a few of the known species; while the whole body is drawn out to such an extent as to make the creature look out of all proportion when compared with the other members of the group. The genus may be described as follows:

Gen. Oripoda Banks and Pergande.

Pteromorphæ very long and narrow, extending almost the entire length of the body, and attached to the cephalothorax as well as to the abdomen. Cephalothorax very long and narrow with the sides almost parallel; covered above by a single, chitinous plate which projects slightly, like a hood, over the mouth-parts (Fig. 1). Cephalothorax completely bare above except for a single pair of bristles. Pseudostigmata entirely covered above by the pteromorphæ, and occupying an extreme postero-lateral position on the cephalothorax. Tarsi of the first two pairs of legs very short and truncate anteriorly (Figs. 5 and

6). Femora of second legs large, flattened and with a lateral blade-like expansion (Fig. 5).

The genus for which *Oripoda elongata* stands as a type will occupy a place next to the genus *Gymnobates* Banks, a genus represented by only two species, both of which are American. It shares with this genus the elongate form of the body and the truncate nature of the tarsi of the first two pairs of legs. The pteromorphæ represent an exaggeration of the form shown in *Gymnobates*, being extended farther forward and united by a transverse ridge at about the middle of the cephalothorax! It differs from this genus in having an elongate, cylindrical cephalothorax, entirely devoid of either the true or the lateral lamellæ; and in the structure of the second pair of legs. The species may be described as follows:

Oripoda elongata Banks and Pergande.

Light chestnut brown.

Cephalothorax very long, cylindrical, fully twice as long as broad; sides of cephalothorax almost parallel. No lamellæ, translamella or lamellar hairs present. A superior pair of bristles present, each pectinate, almost straight and about as long as the tibia of leg I. There is a slight, chitinous ridge connecting the two pteromorphæ, which passes transversely across the middle of the cephalothorax. Pseudostigmatic organs, short, capitate and entirely concealed by the pteromorphæ.

Abdomen cylindrical, about twice as long as broad. Pteromorphæ very long and narrow, extending the entire length of the abodmen and for about one-half the length of the cephalothorax. The abdomen bears dorsally about twenty rather small, slightly curved, pectinate bristles. There is an anterior lateral marginal pair; a dorsal pair; a posterior terminal pair; and about seven pairs situated upon or near the base of the pteromorphæ. Genital covers (Fig. 3) each about one-half as broad as long and semi-disc-shaped. They are situated over twice their length in front of the somewhat larger anal covers. Anal covers (Fig. 3) subrectangular in shape and almost approximate to the posterior margin of the ventral plate.

Anterior pair of legs extending about one-half their length in front of the tip of the cephalothorax; tarsus of leg I two-thirds as broad as long, truncate anteriorly; tibia twice as long as the

tarsus; genual slightly over one-third as long as the tibia; femur as long as tibia; coxa almost completely hidden in its socket (Fig. 4), where it has a double hinge upon which it rotates. Second pair of legs (Fig. 5) shorter than the first and normally bent at the genual; tarsus of leg II almost as broad as long; tibia much broader distally than proximally; genual slightly longer than broad; femur of a very peculiar shape, being much flattened, with an expanded latero-ventral margin; coxa as in leg I. The last two pairs of legs are of the common type; the last extending slightly beyond the tip of the abdomen. Ungues tridactyle; dactyles equally developed. Length 0.42 mm.; breadth 0.22 mm.

I have examined the mouth-parts of this species in hope that they would show some peculiarities, especially since this species has a rather extraordinary habitat, but they present the typical acarid form (Fig. 1); however, they are somewhat weaker than usual. The mandibles (Fig. 2) appear to be normal. The internal anatomy presents no special peculiarities. The organs are less compact than in the common species, as would be expected, because of the drawn-out form of the body. The ventriculus, or stomach, and its cæca appear to be rather small, but this is probably due to the shrinking of the tissues. In the females often there can be seen several large developing ova. The ovipositor is rather longer than usual.

Explanation of Plate XXIX.

Fig. 1. Mouth-parts as seen from below.

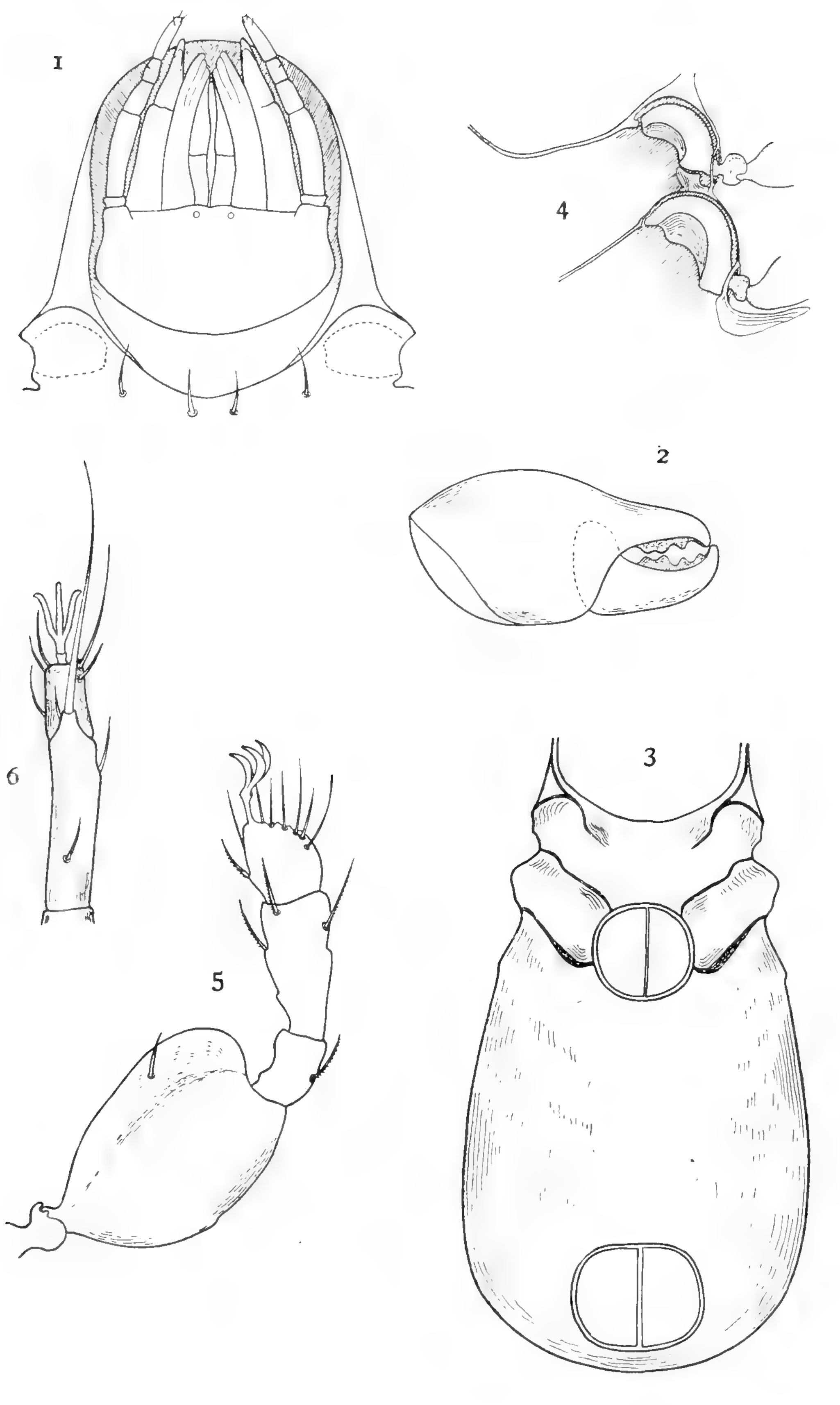
Fig. 2. Side view of one of the mandibles.

Fig. 3. Ventral surface of the body.

Fig. 4. The coxæ of legs I and II as seen from below, so as to show their double-hinged arrangement.

Fig. 5. Inside of leg II.

Fig. 6. Tarsus and tibia of leg I.



H. E. Ewing.

A REVISION OF THE AMERICAN SPECIES OF PLATYMETOPIUS.

By E. P. Van Duzee,
Buffalo, N. Y.

The Hemipterous genus *Platymetopius* was founded by Burmeister in 1838 in his Genera Insectorum for the European *rostratus* H. S. and *vittatus* Fabr (= *undatus* DeGeer,) the former of which should doubtless be taken as the type. It is widely distributed in the palearctic and nearctic regions. Twelve species have been recorded from the former and from the latter twenty-three are enumerated in the present paper. Three additional species have been described from tropical America, where the genus may be well represented.

This genus is easily distinguished from the allied Jassid genera by the long pointed vertex, the narrow front and the strong elytral venation. There are three anteapical and five apical areoles in the elytra of which the outer is broadly triangular; the second sector is connected with the branches of the first by two transverse veinlets and there is usually a series of eight or ten oblique veinlets crossing the costal areole. The elytra in the more typical species are more or less closely inscribed with fine brown or fuscous pigment lines and ornamented with a few oval or rounded whitish spots placed near the ends of the areoles of which those occupying the apex of the anteapical and the base of the apical are most regular and persistent. The angled base of the front usually has a concentric pale or white line a little below the sharp edge of the head where there is frequently a second line; these lines being accentuated by darker borders. In the paler faced species these lines may become obscure or entirely obliterated. In fully marked species there are usually five longitudinal pale vittæ on the pronotum and about five white calloused spots on the margins of the scutellum of which three are on the angles of the posterior field. The characters of the genitalia are quite distinctive in some of the species but in most they run so close that they are of little value for diagnostic purposes.

I do not now like to express any very decided views on the phylogeny of this genus but in a linear arrangement of the genera I would certainly place it between *Mesamia* and *Delto-*

cephalus. Through the former it is related to the *Dorydini* and through the latter with the *Athysanini*, while with this last tribe it is independently connected by genus *Scaphoideus*. I still adhere to the views expressed by me many years ago as to the value of the second cross nervure between the first and second sectors of the elytra as a diagnostic character in the Jassid genera. It is but one character among several which unite a fairly homogeneous group of genera with *Mesamia* at one extreme and *Deltocephalus* at the other. The form of the vertex alone can never be used for separating the Jassid genera into groups nor do I know of any other single character so available as is the elytral venation. That certain species of *Athysanus* or *Eutettix* show an occasional second cross nervure only proves to me that those genera have but recently developed from their parent stem and are still plastic. The whole group of genera included by me in the *Deltocephalini* and *Athysanini* seems now to be in their ascendancy and rapidly developing in both species and genera, many of which have not yet become well differentiated.

In the preparation of this paper I have had before me representatives of all but two of the described American species, *modestus* and *elegans*. The latter however is a distinct species well known to me and it has been included in the synoptical table. Of the others I have examined the types of all but *acutus* Say, *madgalensis* Prov. and *cinereus* O. & B., the two former of which certainly refer to our most abundant eastern species.

I wish here to extend my thanks to those who have assisted me with the loan of material. To Prof. Herbert Osborn I am indebted for a number of his types and the opportunity of examining all the material in his collection and in that of the Ohio State University at Columbus, Ohio; Dr. Ball has sent me his very valuable material in the genus including the types of the species recently described by him; and at the suggestion of Prof. Baker, Dr. Howard has kindly sent me the types of the three Baker species described in 1900 and with them examples of ten other species from the National Museum collection. In addition to this my own collection contains representatives of twenty species mostly in good series. From this material I have found it necessary to describe as new four species and one variety.

In preparing the following dichotomous table of the species I have used the most available characters I could discover. Many of these characters are obscure or difficult to express in words which is especially true of the markings of the vertex although these markings seem to be good and constant characters. It must be borne in mind that the vertex in the female is always longer and more acute at apex than in the male. Unfortunately the type of *tenuifrons* Baker was received too late to allow of its being included in the key to the species but its long vertex with a peculiarly broad and rounded apex and the brown face will readily separate it from *verecundus* to which it is most closely related.

KEY TO THE SPECIES OF PLATYMETOPIUS.

Elytra uniformly whitish-hyaline crossed by three narrow but usually well distinguished fuscous vittæ; oblique costal veinlets wanting; vertex rather short,
1. **hyalinus** Osb.

Elytra more or less hyaline, usually pigmented and veined or inscribed with fuscous with the costal areole hyaline and crossed, at least at apex, by oblique fuscous veinlets; never uniformly hyaline with narrow transverse vittæ.......... 1.

1. Elytra quite uniformly colored or subhyaline with at most but slight veining toward the apex; oblique veinlets of the costa wanting anterior to the anteapical areoles.......... 2.

–. Elytra white or whitish hyaline more or less clouded with fulvous or cinereous and inscribed with fulvous-brown or fuscous, at times almost entirely fulvous or black; oblique veinlets at least indicated in the costal areole
3.

2. Color a polished sub-hyaline brown; vertex large, parabolic, dull fulvous; clavus and a broad band across the anteapical areoles which extends back along the costa, whitish; face deep black with the edge and an angulate line white, conspicuous; length 4 mm.; inhabits California.
3. **majestus** Ball.

–. Color greenish or creamy white; vertex of the male short, about right-angled, of the female strongly produced, lineated at apex with brown and pale; elytra slightly infuscated at apex with about three oblique veinlets against the anteapical areoles; length 3½–4½ mm.............2. **nigriviridis** Ball.

3. Elytra but partially clouded and inscribed, marked with a conspicuous yellow dorsal stripe along the closed elytra; inhabits California.
4. **elegans** VanD.

–. Elytra variously clouded and inscribed but without a conspicuous pale dorsal vitta.......... 4.

4. Vertex flat, Thamnotettix-like, not depressed nor channeled toward its apex, anterior margin rounded to the front; pronotum and elytra recalling *Mesamia vitellina*, wanting the white areolar spots of *Platymetopius*.
13. **dorsalis** Ball.

–. Vertex more or less channeled toward the apex which may be depressed or produced and a little elevated; anterior edge thin, acute or subacute....5.

5. Face pale or yellow, usually more or less infuscated at base and sides, the former frequently marked with an angulate pale line....................6.

–. Face entirely brown or fuscous..18.

6. Markings of the vertex in the form of lineations, usually a pale median line more distinct anteriorly and edged with brown, and a faint slightly divergent line either side..7.

—. Pale markings on the vertex taking the form of a broken transverse vitta before the eyes, more or less complete, the median line short and apical. 15.

7. Elytra subhyaline, either cinereous or fulvous, usually clouded and reticulated anterior to the anteapical areoles with the white areolar spots apparent; angular white line on the base of the front distinct (except in *latus*) .... 8.

—. Elytra fulvous and opake anterior to the anteapical areoles, the white areolar spots obscure in the female, obsolete in the male .... 14.

8. General color cinereous with the elytral markings and areolar spots distinct; beneath mostly black; face distinctly infuscated at base and sides...... 9.

—. General color fulvous with the elytral markings usually indistinct and the lower surface pale; face but slightly infuscated on the sides, the angular basal mark nearly obsolete.. 10.

9. Length 5 mm.; vertex of the male little longer than the width between the eyes, of the female somewhat longer; inhabits from Canada to Georgia. 5. **acutus** Say.

—. Length 4 mm.; vertex very long and pointed, at least twice as long as wide between the eyes; inhabits Florida.................. 9. **slossoni** VanD.

10. Face obscurely infuscated on the sides, the angular white line at base distinct. 11.

—. Face uniformly yellowish, the angular white line at base obsolete; vertex at least twice as long as wide between the eyes; elytral reticulations and areolar spots obsolete at least in the female............ 7. **latus** Baker.

11. Length at least 5 mm.; general color fulvous............................ 12.

—. Length 3½-4 mm.; color cinereous, usually tinged with greenish. 10. **cinereus** O. & B.

12. Male plates short and broad, hardly passing the middle of the pygofers; areolar spots practically obsolete anterior to the anteapical areoles; general color darker, the males clearly marked........ 8. **cuprescens** Osb.

—. Male plates long triangular, but moderately exceeded by the pygofers.... 13.

13. Last ventral segment of the female scarcely longer than one half its basal width; male plates narrow; pronotal vittæ usually distinct. 5. **acutus** var. **dubius** VanD.

—. Last ventral segment of the female long and narrowed to the nearly truncated apex; much longer than one half its basal width; male plates large and broad; pronotal vittæ obsolete .... 6. **oregonensis** Baker.

14. Larger, 4½–5 mm.; valve of the male distinctly angled at apex. 12. **fulvus** Osb.

—. Smaller, 3–4 mm.; valve of the male scarcely angled at apex. 11. **angustatus** Osb.

15. Face pale or yellow, infuscated at the sides.......................... 16.

—. Face entirely yellow, sometimes showing obsolete irrorations quite uniformly distributed .... 17.

16. Vertex more obtuse; sides of the face distinctly and abruptly darker; the angulate pale line at base obvious across nearly the whole width of the face; vertex mostly black......................... 14. **frontalis** VanD.

—. Vertex more produced; face showing traces of darker irrorations especially at the sides; angulate basal line reduced to an angled transverse spot; vertex mostly white, the markings of the whole upper surface more strongly contrasting... 15. **nasutus** VanD.

17. Vertex longer, about as in *nasutus;* pleuræ and legs mostly fuscous brown; inhabits Florida to Colorado and Mexico.......... 16. **loricatus** VanD.

—. Vertex shorter, about as in *frontalis;* pleuræ and legs whitish or mostly so; inhabits Jamaica................................. 17. **nanus** VanD.

18. Male plates triangular, their apex acute or subacute; last ventral segment of the female long with its apical margin oblique either side of the middle which is distinctly produced and sometimes abruptly angled.......... 19.

—. Male plates short, transverse and rounded at apex, little exceeding the valve; last ventral segment of the female short, truncate, its hind margin a little sinuated... 24. **fuscifrons** VanD.

19. Larger, 5 mm.; white markings of the vertex scarcely forming a transverse vitta before the eyes, consisting of the apical line, a curved mark either side, and sometimes two dashes behind these, and four approximate marks on the base; inhabits eastern states and Canada. ....21. **obscurus** Osb.
 Smaller species, 3½-4 mm.; markings of the vertex forming a transverse vitta before the eyes. ....20.
20. Vertex forming at least a right angle before, the apex subacute........21.
 . Vertex short, rounded at apex........23.
21. Vertex strongly produced, almost acute at apex, its length nearly or quite twice the width between the eyes; pale markings complete but not strongly contrasted; transverse vitta interrupted at the middle and sometimes on either side; inhabits Florida........19. **verecundus** VanD.
 -. Vertex shorter, scarcely more than right angled at apex........22.
22. Vertex paler at base shading to fuscous anteriorly; transverse vitta of four subequal white dashes; apical dash short, isolated; areolar white spots few but well distributed over the elytra; inhabits California and Mexico.
18. **irroratus** VanD.
 -. Form of *frontalis* nearly; general color darker or blackish-fuscous; areolar white spots clustered about the apical transverse nervures; white markings on the vertex consisting of the apical line, a marginal line either side, two larger spots representing the transverse vitta, and two others at the base; inhabits Kansas........20. **scriptus** Ball.
23. Anterior edge of the head marked with five uniform contiguous white spots; angled white line on the base of the front represented by a small but distinct transverse spot; inhabits Jamaica........23. **brevis** VanD.
 -. Anterior margin of the head marked with a white apical point and an obscure pale patch either side about the ocelli; white mark on the base of the front represented by a short slender arcuated line; inhabits Guatemala.
22. **osborni** VanD.

1. **Platymetopius hyalinus** Osborn.

Ent. News, xi, p. 501, 1900.

This insect is quite aberrant in its genus by its uniformly whitish hyaline elytra crossed by three narrow fuscous bands. Prof. Osborn described it from a series taken from an imported tree at Washington, D. C., and strongly suspected that it might be an exotic form introduced with material added to the Botanical Gardens there. In that case it probably has become acclimated as Mr. C. W. Johnson has sent me a specimen he took near Philadelphia.

2. **Platymetopius nigriviridis** Ball.

Ent. News, xx, p. 163, 1909.

Another very distinct little species from California. It is of a pale straw color tinged with green especially on the head, anterior margin of the pronotum and abdomen. On the elytra there is a longitudinal line on the clavus, some of the discal nervures near the apex, about four of the oblique costal veinlets posteriorly, and a spot at the apex of the inner apical areole blackish. Face immaculate. Vertex of the male short, about right-angled at apex; of the female strongly produced but little shorter than in *slossoni*. The variety **dixianus** Ball is still

paler with the vertex of the female shorter and similarly lineated with fuscous at apex. This variety, of which I have seen only the types, is from Utah.

3. **Platymetopius majestus** Ball.

Ent. News, xx. p. 164, 1909.

A small but very distinct species thus far reported only from California. Its deep black face marked with a white basal edge and concentric line, the large pale yellowish parabolic vertex and the brownish iridescent and uninscribed elytra make its identification easy . I have seen only the types which were kindly loaned to me by Dr. Ball.

4. **Platymetopius elegans** Van Duzee.

Ent. Americana, vi, p. 94, 1890.

In this species there is a broad yellowish dorsal stripe from the middle of the vertex to the tip of the clavus. The corium is brownish-cinereous obscurely banded with whitish hyaline, the cinereous areas are minutely inscribed with fuscous, the apical submargin and some of the adjacent nervures are heavily embrowned and the clavus and disk of the corium are sprinkled with obscure rufous dots. The lower surface is yellowish with the base of the face cinereous and the angled pale line distinct. The vertex of the female is about one half longer than the width between the eyes. Length 5 mm. I have seen only the unique female type which was from California but among my Florida captures was one apparently scarcely mature specimen showing a similar yellow dorsal vitta, which I cannot identify with this species. It may represent a still undescribed form.

5. **Platymetopius acutus** Say.

Jl. Acad. Nat. Sci., Phila., vi, p. 306, 1831; Compl. Writings, ii, p. 382.
Platymetopius magdalensis Prov. Pet. Faun. Ent. Can. iii, p. 275, 1889.

This, our most widely distributed *Platymetopius*, seems to be the stem form from which have branched off most of the closely allied species found in this country, to all of which it is connected by certain variable characters. Its typical form, agreeing perfectly with Say's description, is found throughout the middle and northern states but in one form or another it occurs from the Atlantic to the Pacific coasts and from northern Quebec and British Columbia to, or nearly to the gulf coast. The typical form may be characterized as follows:

Vertex in the male a very little longer than broad between the eyes, in the female distinctly longer. Color: Vertex fulvous-brown finely

irrorate with testaceous forming a longitudinal line next each eye and another midway between that and the median sulcus; a line at apex, an oblique mark either side of this and four marks on the basal margin white bordered with piceous black. Pronotum fulvous-brown, closely, confluently irrorate with testaceous-white and showing five whitish longitudinal vittæ more or less conspicuous. Scutellum fulvous with four spots on the anterior field and the three angles of the posterior field whitish, outlined in black, the disk of the anterior field sometimes variegated with pale. Elytra white, rather closely inscribed with fulvous brown; nervures darker brown; costal area white crossed by nine or ten heavy oblique veinlets; round areolar white spots most conspicuous in the apex of the anteapical areoles, the base of the apical, and near the tip of the claval. Face light yellow, abruptly shading to fuscous on the base of the front and outer half of the cheeks, the former marked with a white angled line and a more slender one follows close under the anterior edge of the vertex; the lower continued as a longitudinal line behind the eyes. Beneath and legs deep black, more or less varied with whitish, the tibiæ white dotted with black at the base of the white spines. Genital characters. Male: Last ventral segment short, broadly and very obtusely excavated. Valve large obtusely triangular, apex rounded. Plates triangular, exceeding the valve by about its own length, their sides rectilinear or more generally slightly convexly arcuated to an obtuse apex, sometimes a little concave with their apex subacute; closely fringed with stiff bristles. Pygofers narrow, distinctly exceeding the plates. Female: Last ventral segment scarcely longer than one half its basal width, moderately compressed suggesting a median carina; viewed from directly below the hind margin is broadly rounded; oviduct scarcely exceeding the pygofers. Length about 5 mm.

Toward the north and west this species varies to a lighter almost fulvous color with little if any black beneath, the face is paler, scarcely shading to darker on the sides of the cheeks, and the vertex is more strongly produced, at least one half longer than broad between the eyes. I call this variety **dubius** to distinguish it from the typical form with which it is connected by almost insensible gradations. It in turn forms a connecting link with *oregonensis*, which however I believe to be a distinct species. I have listed this species as *latus* in Canadian Entomologist, xl, p. 157, 1908.

6. **Platymetopius oregonensis** Baker.

Can. Ent. xxxii, p. 49, 1900.

This species was described from two males from Oregon but Dr. Howard has sent to me from the Baker collection one male and one female marked as types. These agree in every particular with material in Dr. Ball's collection and my own from California, Utah, Colorado and New Mexico. In the male the

vertex is shaped almost exactly as in the male of *acutus*, but it is shorter than in the female *acutus* with which sex I assume Prof. Baker may have compared his specimens. The female has a much longer vertex, its length being somewhat more than twice its width between the eyes. In color this species is still paler than in the variety *dubius* of the preceding species. It is of a light fulvous, paler and almost immaculate beneath; the face is pale with but very faint infuscation on the base of the front and sides of the cheeks but with the angular white lines on the former distinct.

This species is best distinguished by the form of the genital pieces: The valve of the male is more angled and subacute at apex; the plates are larger with their outer margins distinctly concavely arcuated and their apices a little divergent and subacute. The last ventral segment of the female is conspicuously longer and narrower than in *acutus* with its apex slightly subangularly produced.

7. **Platymetopius latus** Baker.

Can. Ent. xxxii, p. 50. 1900.

I have one female of this species taken by Mr. W. J. Palmer of this city at Quinze Lake, Quebec, which agrees perfectly with Prof. Baker's Colorado type received from Dr. Howard. It may be distinguished by its fusiform shape, narrow pointed head with a vertex twice as long as its width between the eyes, the broad flaring elytra, the almost uniform coloring which is fulvous-brown above, without irrorations on the vertex, pronotum and scutellum, and almost without elytral reticulations or white areolar spots, the nearly concolorous nervures, those of the costal areole being a little more distinct, and the uniformly pale yellowish-testaceous coloring beneath with the base of the front darkened only at the extreme tip and not showing the angular white mark. Genital characters nearest to those of *acutus*; the last ventral segment a little more angled and the pygofers smaller. This is a rare species and probably is confined to northern Canada and the higher regions of the Rocky Mountains.

8. **Platymetopius cuprescens** Osborn.

20th Rept. N. Y. State Ent. p. 517, 1905.

Another closely allied species which comes nearest to *acutus* but has a longer and sharper vertex, about as in *dubius* and *oregonensis;* the elytra are more infuscated with but slight traces

of the white areolar spots. The face is pale yellow, but little darkened on the base of the front and sides of the cheeks, with the pale angular line distinct. The genital characters of the female are very close to those of *acutus*, but the last ventral segment is more carinated with its apex distinctly notched when viewed from below. In the male these characters are very distinctive. Last ventral segment longer, not shorter, than the preceding; valve shorter; plates much shorter, rounded, about two thirds the length of the valve; pygofers broad, exceeding the plates by about the length of the latter and similar to them in color and texture. Prof. Osborn's type was taken by me at Phoenicia, N. Y., I have taken another female at Niagara Falls and a male at Boulder, Colorado, and another at Ogden, Utah, and Mr. Palmer took one at Quinze Lake, Quebec.

9. **Platymetopius slossoni** n. sp.

Very close to *acutus* but smaller with a longer and more acute vertex and shorter male pygofers. Length 4 mm.

Vertex long and acute at apex, still longer than in *oregonensis* and *latus* rather more than twice as long as wide between the eyes and obviously longer than the pronotum and scutellum together; marked with three pale longitudinal lines as in *acutus;* the lateral curved, becoming approximate and parallel for a short space at base. Face light yellow with the angled base of the front and sides of cheeks broadly distinctly infuscated, the former with a very distinct acutely angled concentric white line which is projected to the apex of the head and is strongly reproduced behind the eyes. Pronotum with the longitudinal vittæ distinct as in *acutus*. Beneath and abdomen dark fuscous; in the female obscurely marked or irrorate with pale in places; last ventral segment shaped as in *acutus*, whitish at base with about four black ligulate marks on the basal margin. In the male the pectus and abdomen are deep black, obscurely marked with pale on the venter and at the tip of the valve; last ventral segment angularly but not deeply emarginate; valve triangular, subacute at apex; plates rather broad-triangular, on their sutural margin as long as the valve, their outer edges moderately sinuated and fringed with bristles, their apex a little narrower than in *acutus;* pygofers slightly but distinctly shorter than the plates which they scarcely exceed at the sides.

Described from one pair taken at Jacksonville, Fla., in May, 1910, by Mrs. Annie Trumbull Slosson whose enthusiasm and industry have added so much to our knowledge of the insect fauna of Florida and other parts of the eastern United States. I took a good series of what is certainly the same species at Crescent City, Sanford, Sevenoaks and Ft. Myers, Florida.

They differ only in being slightly larger and paler. This species is very close to *acutus* with which the typical form is almost identical in color and markings but its small size, remarkably long and acute vertex and the short male pygofers preclude its reference to that species.

10. **Platymetopius cinereus** Osborn & Ball.

Proc. Iowa Acad. Sci. iv, p. 193, 1897.

This is a very small and somewhat greenish species with a vertex formed about as in *acutus;* face greenish-white, very slightly infuscated on the base of the front where the angular white line is distinct; markings on the vertex and pronotum nearly obsolete but the five pale vittæ of the latter are generally discernable; abdomen mostly black in the male, rarely so in the female; elytra closely but lightly reticulated. Last ventral segment angularly produced in the female; valve of the male obtusely triangular; plates nearly as long as the valve on their suture, triangular, blunt at apex, considerably exceeded by the pygofers.

This, one of our smallest species, is found throughout the warmer portions of the central and southern states from Iowa to Florida.

11. **Platymetopius angustatus** Osborn.

20th Rept. N. Y. State Ent., p. 518, 1905.

Prof. Osborn has very kindly sent me one of his male types and I have examined the female in his collection. This is the smallest species known to me and has been reported from the type locality only: Long Island, N. Y. The female is distinctly larger with a longer vertex than the male. It has a light greenish color with coppery reflections; the round areolar spots of the elytra are confined to the apical and anteapical areoles; the costa is hyaline with the oblique veinlets dark and the abdomen is marked with black. The male is smaller with a much shorter vertex; its color is a bright fulvous becoming yellowish on the head; the elytra are subopake, almost unicolorous on their base but becoming recticulated with brown on their apical and anteapical areoles where the round white spots are fairly distinct; oblique veinlets of the costal areole almost obsolete. In both sexes the base of the front is feebly infuscated with the pale angular line discernible.

Last ventral segment of the female rounded. Valve of the male large scarcely angulate at apex; plates triangular, on their suture shorter than the valve; terminated by the long setæ; the brown apex of the pygofers much surpassing the plates.

12. **Platymetopius fulvus** Osborn.

20th Rept. N. Y. State Ent., p. 519, 1905.

This insect has about the form and size of *frontalis* but it is of a bright fulvous color with the elytra mostly opake and the markings almost or quite obliterated from the base nearly to the apex of the ante-apical areoles; vertex and scutellum more yellowish with indistinct pale vermiculate lines; oblique costal veinlets brown on a concolorous ground; face almost uniformly pale yellow with the basal angular pale line rarely indicated.

Last ventral segment of the female rounded behind with a blackish arcuate mark either side which gives it the appearance of being strongly produced on the middle. Valve of the male ovate-triangular, its margins arcuated to the obtuse apex; plates large, triangular, exceeding the valve by its own length; strongly ciliate on their outer margins; pygofers slender, longer than the plates.

Prof. Osborn's types were from Cold Spring Harbor, Long Island, N. Y. About Buffalo it is not uncommon among the hills at Colden and Gowanda and it has been reported from Pennsylvania and Ohio.

13. **Platymetopius dorsalis** Ball.

Platymetopius frontalis var. dorsalis Ball. Ent. News, xx, p. 164, 1909.

I cannot agree with Dr. Ball in placing this as a variety of *frontalis*. It seems to me very distinct and withall a difficult species to place. It is fulvous and pale yellow in color and has much the aspect of a small *Mesamia vitellina* but it has the vertex of a *Thamnotettix* and the front of a *Platymetopius*, to which genus I think it is most closely allied by its venation and structural characters. The anterior edge of the head is obtusely rounded as compared with the allied species. The lower surface, vertex and scutellum are pale yellow and immaculate. The pronotum and elytra are bright fulvous with coppery reflections, with the sides of the pronotum, costa at base, apical areoles and a vague saddle across the apical half of the clavus yellowish. I have seen only the unique type from Kansas kindly loaned to me by Dr. Ball.

14. **Platymetopius frontalis** Van Duzee.

Can. Ent. xxii, p. 112, 1890.

Common and widely distributed throughout a great part of the United States and Canada. This species may be distinguished by its stout form, short vertex and blackish color both above and below, with a clear yellow face which becomes infuscated at each side but scarcely at the pointed base where the angled lines are but poorly distinguished. The vertex has a white median dash at apex and a transverse vitta of similar marks across the disk before the eyes, more or less conspicuous. The pronotum sometimes shows faint traces of the five pale vittæ and there may be some white marks on the scutellum forming two broken longitudinal vittæ. Elytral areoles with pale reticulations about their margins, sometimes nearly obsolete in the males; round areolar spots well developed and conspicuous; costa white, the oblique veinlets heavy; apical areoles generally infuscated beyond the white basal dots, the extreme edge clear white. Male genital characters about as in *fulvus;* the valve broader and more rounded and the plates a little shorter; last ventral segment of the female short and broadly rounded on the apical margin. Dr. Ball has sent me for inspection a typical example of *frontalis* taken by Prof. Gillette in Mexico.

15. **Platymetopius nasutus** Van Duzee.

Bul. Buf. Soc. Nat. Sci. viii, No. 5, p. 64, 1907.

While very close to *frontalis* I believe this a sufficiently distinct species. The vertex is obviously longer and more pointed and there is much more white in the coloring of the upper surface. The vertex is mostly white with the apex and a transverse eroded vitta black, the former with a median line and two oblique dashes white; the pale basal portion is veined with fuscous and the white median area is crossed by a black longitudinal line either side of the middle; the pronotum is irrorated with white and fuscous with the anterior margin and depressed sides mostly white and the longitudinal vittæ scarcely indicated. The elytra are white with a few fulvous-brown areas in the areoles and with fuscous reticulations more or less extended, the white areolar spots being much obscured. Beneath black with the tibiæ and tarsi white, dotted with black; the femora sometines largely invaded with white.

In this species the face while mostly yellow shows a strong tendency to a uniform fuscous irroration which becomes more conspicuous laterally (thus forming a connecting link with the group of brown-faced species), and the angled base may also be darkened, with a transverse crescentic white mark. The male plates are proportionately a little larger and more obtuse at apex than in *frontalis* and the last ventral segment of the female is shorter and more angled. The types of this species were from Jamaica and Colorado and I have seen others from California.

16. **Platymetopius loricatus** Van Duzee.

Bul. Buf. Soc. Nat. Sci., v., p. 205, 1894.

Allied to *nasutus* but sometimes smaller and showing strong indications of the frontal irrorations found in *fuscifrons*. Face in typical examples entirely pale yellow. Vertex shorter than in *nasutus* but longer than in *frontalis;* its markings substantially as in *frontalis* but here the white vitta consists in great part of two longer approximate and dislocated white dashes and a few minute irrorations, the base with two median white dashes. Pronotum with the five pale vittæ fairly distinct. Elytra mostly blackish as in *frontalis* but with the white areolar spots smaller and fewer anteriorly. Face frequently showing strong indications of fuscous irrorations, especially toward the base of the front where there is then a short angled white mark. Last ventral segment of the female short, its hind margin hardly angled at the middle, the lateral angles rounded. Valve of the male short and rounded or very feebly angled; the plates broadly but acutely triangular, scarcely longer on their suture than the valve; slightly exceeded by the pygofers. Described from California but I have seen others from Colorado, Florida, Orizaba, Mexico, and Gualan, Guatemala.

17. **Platymetopius nanus** Van Duzee.

Bul. Buf. Soc. Nat. Sci , viii, No. 5, p. 65, 1907.

Very close to *loricatus* but the colors are paler with the white elytral spots less distinct, the pleura are yellow with a brown cloud anteriorly, not black as in *loricatus*, and the vertex is a little shorter but similarly marked. The last ventral segment of the female is more produced. In the male the last ventral segment is subangularly excavated behind; the plates also are larger and white, surpassing the apex of the pygofers which is not the case in *loricatus*.

The aspect of these two species and the next shows a greater difference than is sustained by their structural characters and it is possible, but I hardly think likely, that material from intermediate localities may necessitate merging them in one. The smaller *nanus* has thus far been found only in the island of Jamaica.

18. **Platymetopius irroratus** n. sp.

Differs from *loricatus* in being paler in color and generally smaller and in having the hind edge of the last ventral segment of the female distinctly angled either side and the plates of the male proportionately shorter but equally acute at apex leaving the margins more deeply arcuated. In this form the face is always more or less irrorated with brown or fuscous or at times entirely pale brown irrorated with pale. In the paler individuals the facial irrorations are always more dense toward its angled base where the pale line is distinct. The vertex is somwehat shorter than in *loricatus* and the elytra are cinereous instead of almost black as in that species. It is close to *brevis* but may be distinguished by the longer vertex which is darkened at apex and marked with four white dashes as in *loricatus*. The genital characters are also quite different from *brevis*. Length 4 mm.

Dr. Ball has sent me a long series of this species taken at Chino, Riverside, Pasadena and San Diego, California, Phoenix, Arizona, and Ti Juana, Mexico.

19. **Platymetopius verecundus** n. sp.

Allied to *irroratus* and *obscurus* but with a longer vertex than in either. Length 3 1-2 to 4 mm.

Vertex about as in *oregonensis*, much produced and acute but distinctly shorter than in *slossoni;* in the female about twice as long as wide between the eyes. Clypeus much constricted near the base with its apex produced and rounded as in the allied species. Hind margin of the last ventral segment of the female distinctly angled and slightly produced at the middle and more obscurely angled on either side. Last ventral segment of the male subangularly emarginate; valve large, scarcely angled at apex; plates as in *loricatus*, a little longer than in *irroratus* and smaller than in *scriptus* and *obscurus*.

Color fulvous-brown with rather strong ornamentation. Vertex marked as in the allied species, the pale apical line more developed; transverse pale vitta sometimes almost entire or broken only by the fulvous median stripe and a brown line near it on either side, or there may be a second interrupting line exteriorly; base with a white median vitta bisected by a fuscous longitudinal line and sometimes terminated outwardly by a similar line. Pale vittæ of the pronotum distinct.

Scutellum distinctly fulvous with the extreme angles and two vittæ irrorate with white. Elytra strongly inscribed; the areolar white spots distinct; costal areole whitish with the oblique veinlets strong; apical areoles narrowly fuscous next to the slender white apical margin. Front fulvous-brown, obscurely irrorate with pale, the white angular mark on the base of the front well developed and reaching about one half way to the eyes. There are two white lines beyond the eyes and an obsolete oblique one at the upper angle of the loræ; pectoral pieces fulvous-brown, conspicuously paler beneath. Abdomen fuscous or brown, varied with pale. Legs pale dotted with fuscous.

Described from numerous examples taken by me in Florida and listed as "*obscurus* Osb.?" in my report on the Hemiptera taken at that time. The exact localities represented are Crescent City, Sanford, Sevenoaks, Clearwater and Estero. This species with *nanus* from Jamaica, *irroratus* from Mexico and *scriptus* from Kansas form a puzzling group of very closely allied forms which run into *loricatus* on one hand and *obscurus* on the other. Their genital characters vary slightly but are not sufficient for separating them. Students with "lumping" proclivities will doubtless place them as varieties of a single species.

20. **Platymetopius scriptus** Ball.

Ent. News, xx, p. 165, 1909.

Male: A little larger and darker with a shorter vertex than in the preceding two species. Closely allied to *frontalis* but with a brown front and differently marked vertex. Last ventral segment nearly as long as the preceding, broadly angularly excavated behind and distinctly carinate on the median line; valve large, produced but scarcely angled at apex; plates large, subacute at apex, sides nearly straight; on their suture much shorter than the valve; considerably surpassed by the pygofers. Color blackish fuscous, nearly as dark as in *frontalis*, paler on the scutellum; white areolar spots present in the apex of the anteapical and base of the apical areoles, elsewhere usually wanting. Face brown, coarsely irrorate with pale, the angular basal mark distinct. Pectus, abdomen and legs black; tibiæ mostly white dotted with black; median apical line and anterior edge of the vertex white; the latter forked about the ocelli and connected with a squarish white spot indicating the transverse vitta of *loricatus;* basal white dashes usually connecting with another exteriorly forming an irregular pale patch. Scutellar angles more or less conspicuously fulvous. Length 4 mm.

Known to me only from the five type specimens kindly loaned to me by Dr. Ball.

21. **Platymetopius obscurus** Osborn.

Ohio Nat. v. p. 274, 1905.

This species very closely resembles *acutus* in size, color, markings and shape of the vertex. The face however is fulvous-brown, coarsely irrorate with paler; the valve of the male is more angled, the plates are smaller and the hind edge of the last ventral segment of the female is more transverse and angled on either side. Length 5 mm.

Described from New York, Pennsylvania and Ohio. Mr. Palmer found it abundant at Lake Temagami, Ont., and Quinze Lake, Quebec. I took it at Sharon and Ipswich, Mass., and have examined others from Georgia.

22. **Platymetopius osborni** n. sp.

Near *brevis* but larger with a shorter vertex. Length 4 to 4 1-2 mm. Vertex scarcely longer than its basal width; anterior margin rounded, the angle at apex hardly indicated. Front broader than in *brevis*, its sides parallel or nearly so to the superior tip of the loræ, then abruptly narrowed to the clypeus. Genital characters substantially the same as in the allied species except that the last ventral segment of the male is shorter and the pygofers are longer, surpassing the plates. Last ventral segment of the female distinctly angled at about the middle of the latero-posterior margins where they are practically rectilinear in *brevis*. Color about as in *brevis* becoming paler in some females. Vertex fulvous-brown varied with darker, base with four pale marks; a line adjoining the eye and the broad apex ivory-white, the latter interrupted by a median vitta forked at apex and a small broken spot half way between this and the black ocelli. Face irrorate with fuscous points which become confluent on the front and base of the cheeks and omit the sides of the clypeus, a vitta on the loræ and another on the cheeks above its suture; pale angled line on the base of the front reduced to a small transverse spot less conspicuous than in *brevis*. Pronotum rather dark with the five pale vittæ distinct. Scutellum tinged with fulvous with a deeper fulvous mark within the lateral angles, the margin with five white spots. Elytra with strong nervures and recticulations, the latter forming a longitudinal median vitta in the anteapical areoles; apex infuscated with the extreme edge white as far as the outer areole; costa crossed by about ten oblique veinlets; the white areolar spots distinct. Beneath and legs varied with pale and fuscous; the disk of the pleural pieces and base of the venter infuscated. The female is paler but with all the markings indicated.

Described from one female and two males from Prof. Herbert Osborn and taken at Los Amates, Guatemala, January 17th and February 28th, 1905, by Prof. J. S. Hine. This can be confused with no species but *brevis* from which it may be

distinguished by its larger size, broader form, shorter and more rounded vertex, the brown vittæ in the anteapical areoles, the longer male pygofers, and the angle on the margin of the last ventral segment of the female. It has somewhat the aspect of *scriptus* but is very distinct in having a much shorter vertex, in the form of the last ventral segment of the male and in the more angled valve.

23. **Platymetopius brevis** Van Duzee.

Bul. Buf. Soc. Nat. Sci. viii, No. 5, p. 66, 1907.

This tiny species is very close to *osborni* but it averages a little smaller, the vertex is a little more angled, the transverse vitta is crowded close to the anterior margin of the vertex and consists of a pale cloud against each ocellus which may be obscurely connected to a pale basal mark either side of the middle. The anterior edge is white and calloused and is nearly or quite twice interrupted on either side forming five conspicuous white marginal spots. The general colors in this species are pale, largely obliterating the white areolar spots on the elytra. It has been found only on the island of Jamaica, unless a series from California in the Ball collection belong here.

24. **Platymetopius fuscifrons** Van Duzee.

Bul. Buf. Soc. Nat. Sci. v., p. 206, 1894.
Platymetopius abruptus Ball, Ent. News, xx., p. 165, 1909.

This is very distinct from any other known dark-faced species by the short transverse male plates and the short truncated last ventral segment of the female. In the male the front is almost black; the vertex is a little more than right-angled at apex and is obscurely marked, with the white apical line distinct. The male is deeply colored as in *frontalis* while the female seems to be paler than the female of that species, but in both sexes the white areolar spots are well developed. I have been unable to detect any characters by which to distinguish *abruptus*, the type of which Dr. Ball has kindly sent me for examination, from *fuscifrons*. This species inhabits Arizona and California.

25. **Platymetopius modestus** Stal.

Of. Vet. Akad. Forh., xi, p. 255, 1854.

This species has not been recognized by later students and from the short description I am unable to place it in my synoptical table. I append a copy of Stal's description:

"Vertice thoraceque flavis, illo apicem versus concavo, longitudinaliter anguste nigrolineato, hoc basi virescente; hemelytris dilute virescentibus, nervis flavescentibus, margine costali albido-subhyalino; subtus dilute flavotestaceus. Long. 8, lat. 2 millim.—American septentrionalis."

26. **Platymetopius tenuifrons** Baker.

Can. Ent. xxxii, p. 50, 1900.

The type of this species was received too late for its inclusion in the synoptical table. It belongs to the group of brown-faced species and really comes nearest to *verecundus* from which it differs at once by its much larger size and the still longer vertex. It has somewhat the aspect of the female *oregonensis* but the vertex is longer, broader, and more rounded at tip. The elytral reticulations and areolar spots are finer but distinct; the general color is more cinereous than fulvous; the front is fuscous-brown irrorated with paler and becomes darker or almost piceous at the pointed base below the short but distinct and acutely angled white line, and the lower surface of the body is varied with pale and brown. The last ventral segment of the male is about as long as the third and is broadly subangularly excavated; valve rather short and broadly rounded; plates broad-triangular and shorter than the valve. The pale pronotal vittæ are obvious but not conspicuous and the vertex is blackened on the immediate apex with a white point at tip and a pale marginal mark on either side and another half way to the eye. The unique male type was taken in November at Chapada, Brazil.

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DIPLOPODA FROM THE WESTERN STATES.

By Ralph V. Chamberlin.
Brigham Young Univ., Provo, Utah.

FAMILY CALLIPODIDAE.

Lysiopetalum mutans sp. nov.

General color of body above dark brown to almost black; a narrow median line of yellow extending from the anterior margin of the second dorsal scutum to the end of the anal scutum; a broader pale stripe of darker caste than that of the median line along each side from the anterior margin of the first segment to the end of the body; lower portion of sides and the entire venter yellowish. Legs yellow on inner or ventral surface proximally, the distal articles commonly darker; dorsally brownish, likewise darker distally. General color of head brown; vertex areolate with dark-brown over a lighter ground; a smoky or blackish brown area between eye and antenna of each side and those of the other, the area narrowing to a median point down the front, the region each side of this elongation areolate like the vertex; clypeus and labrum light brown to yellow. Antennae deep brown or blackish excepting the two distal articles which are whitish.

Vertex of head crossed by a narrow median longitudinal furrow which is subdivided by a fine line-like elevation; head depressed transversely a little ventrad of bases of antennae; subdensely hirsute with short stiff hairs or setae which are somewhat longer in the clypeal region.

Gnathochilarium broad; greatest width of mentum 3½ times as great as the median length; lingual lamellae, exclusive of its processes, twice as long as the greatest width.

Eyes well developed, black, subtriangular; the ocelli numerous, compactly and seriately arranged. Below eye area proper on each side is what appears to be an organ of sense; it is much larger than an ocellus, convexly elevated and transparent, the convex portion apparently covering a pit in which is a conical body like a sense-cone of the antennae.

Antennae long and moderately clavate; clothed with mostly short hair intermixed with some longer ones; length 2 mm.

Body gradually attenuated from near anterior end of caudal third of the length cephalad, more abruptly narrowed or constricted over several segments immediately caudad of the head. Dorsum depressed or sub-complanate, rather more convex cephalad than caudad. Sides sub-vertical. A fine median dorsal keel extending from the anterior margin of the second segment to the caudal end of body. Each side of the median keel upon the dorsum are three conspicuously elevated, sharp edged carinae which extend entirely across the segment and each of which bears at its caudal end a short clavate seta projecting dorso-caudad; laterad of the outermost of these dorsal keels is a much thicker keel with wide flat surface which bears a similar seta adjacent to caudal end; between each two of these major carinae is an intermediate lower carina which bears no seta; on the side ventrad of the thickened carina above mentioned are two additional, large setigerous carinae and between the thickened carina and the first and between the first and second of these a lower non-setigerous carina; while ventrad of the second are other lower carinae which become obscure ventrad. Segments anteriorly transversely furrowed, the carinae over and cephalad of the furrow lower and weaker but continuous. On the second, third and fourth segments the setae are not borne at caudal ends of the carinae but spring from tubercles contiguous with the carinae at or cephalad of their middles and extend vertically from the surface or nearly so; on the fifth segment are two series of setae, one consisting of setae along caudal margin as on more posterior segments, and the second more cephalad as on the preceding segments, the setae of the two series alternating.

Collum or first segment in outline half-moon shaped, the caudal margin being straight and the lateral and anterior margins together evenly convexly rounded or semicircular. Carinae extending only across the posterior half of the segment, the setae being borne at their cephalic ends. A second series of setae toward the cephalic margin.

Anal plate triangularly narrowed caudad, the posterior margin truncate or weakly widely rounded and bearing the usual two long setigerous papillae; anteriorly, longitudinally carinate; bearing transverse rows of setae of which the most caudal become longer and conspicuously and finely drawn out apically.

Anal valves smooth; an obliquely transverse, somewhat curved impression over caudal portion on each side; each valve bearing two pointed setae, one at the caudal edge and one at middle toward the mesal margin.

Anal scale transversely somewhat diamond shaped, the meso-caudal and meso-cephalic angles a little rounded; a longitudinal, somewhat incurved, impression crossing each side; bearing two pairs of finely pointed setae, one median and between the longitudinal impressions and the other near the caudal margin with each seta laterad of the impression of the corresponding side.

Distal article of first and second legs in the female with a comb- or calamistrum-like series of setae along the ventral surface, the setae being very closely and regularly set.

In the female the coxae of the second to eighteenth legs inclusive and of the twentieth or, as appeared in one specimen, of the second to nineteenth legs inclusive, bear on their caudo-ventral faces conspicuous, distally inflated, sub-fungiform outgrowths; the processes of the third legs, however, reduced to smaller, low convex elevations.

Oviducts of female protruding as greatly elongated appendages or ovipositors which when extended caudad reach the eighth segment of the body; distal portion of processes enormously enlarged, bearing very long stiff bristles; proximally glabrous; showing a tendency to segment into articles; color white.

Number of segments 49 to 53.

Length 26 mm. Width 1.5 mm.

Locality—Stanford, Cal. (W. M. Mann).

FAMILY CRASPEDOSOMIDAE.

Conotyla deseretae sp. nov.

Dorsum brown; a dark band of black or bluish black color along each side immediately ventrad of the carinae, the band commonly extending dorsad on the prozonites and sometimes, especially on the posterior segments, forming thus a band entirely across the dorsum; a median longitudinal dark band along dorsum, and this typically geminated throughout its entire length by a narrow light line. Venter and legs paler, light brown to yellowish. Head commonly a considerably darker, more reddish, brown than that of the body. Antennae deep brown to blackish.

Head widely and shallowly depressed or furrowed transversely between the eye patches. Evenly hirsute with short hairs.

Lingual lamellae of gnathochilarium with sides sub-parallel for most of length; their length, inclusive of processes, three times the greatest width. Lingual stili conspicuous, their lateral teeth distinct. Spatula large, distally broadly rounded. Stipites a little less than five times as long as the greatest width. Mentum with greatest diameter somewhat more than twice the greatest length; its anterior margin widely rounded; as a whole sub-semicircular in shape.

Eye patches triangular, the apex directed forward; ocelli 25, more or less, arranged mostly in seven series (6, 5, 5, 4, 3, 2).

Antennae long, of typical form and proportions; length 3.5 mm. See Pl. XXXI, fig. 8.

Body strongly narrowed caudad and cephalad, the first segment constricted in the usual way; a sharp, low, median keel extending along dorsum for its entire length, a narrow furrow impressed each side of the keel. Second segment short, the inner bristles relatively farther laterad than on the first, and these bristles located more and more distantly from the median line on subsequent segments back to the middle region of body. The lateral bristles, as usual, becoming directed more and more strongly caudad in proceeding from anterior segments posteriorly. Inter-segments or prozonal divisions in part encircled by a series of fine transverse impressed lines, the elevations between these crossed with fine striations.

First segment somewhat semi-circular or sub-reniform, the anterior median region extending into broad excavation of head. Carinae very weak, continuous with the finely raised line of cephalic margin. The inner bristle on each side more than one-third the distance from the distinct longitudinal median keel to the outer bristles. The two outer bristles of each side upon carina, extending dorso-laterad and the caudal one in a transverse line with the inner ones.

Anal scutum truncate caudad, but the caudo-lateral angles extended, the intervening margin widely set in.

Anal valves equalling the scutum; the caudal margin of each nearly straight or but little curved, distinctly raised; an impressed longitudinal line toward dorsal margin and a similar one toward the mesal; three bristles borne a little cephalad of the caudal margin, the uppermost of these being close to the anal scutum, and the lowermost near the middle line of the valve.

Anal scale trapezoidal, the caudal margin wide, widely weakly incurved; a long bristle borne near each caudo-lateral angle.

First two pairs of legs of male slender, six-jointed as usual; the claws large; without special protuberances, and with no roughenings on the distal articles.

Third legs stout and, like the subsequent ones, seven-jointed; the ultimate joint roughened over the ventral and ventro-lateral surfaces, except proximally, with rows of short transparent processes; femur swollen into a wide enlargement on the dorsal side.

Fourth and fifth legs of male similar to the third but with the dorsal face of femora not bulging.

Sixth legs of male like the fifth but the coxae bulging ventrad.

Seventh legs of male with coxae strongly bulging ventrad into prominent rounded processes as shown in the figure (Pl. XXXII, fig. 6).

Anterior pair of processes of male gonopods broad plate-like structures with teeth along mesal portion of distal edge; posterior pair large, strongly inclined caudad, a secondary, somewhat flattened, accessory division along proximal portion of caudo-lateral surface; a conical process springing from the base of each (see Pl. XXXI, figs. 4, 5, and 6.)

Eighth legs or accessory gonopods with the distal article strongly enlarged as usual, the basal article more than commonly elongate, and extended ventro-mesad into a conical process which bears distad a number of very long bristles; below the conical process the proximal joint is shallowly excavated for the reception of a rounded protuberance of the posterior gonopod of the corresponding side.

Length 23 mm.; width 2.9 mm.

Locality—City Creek, Mill Creek, Provo and other canyons of the Wahsatch Mountains, Utah.

Conotyla coloradensis sp. nov.

Dorsum and sides brown, the prozonal divisions of segments somewhat lighter than rest; sometimes finely areolated with paler brown. Lower region of sides and the venter paler, light brown to yellowish. No black bands or spots. Legs yellowish proximally, the distal joints brown or marked with brown in spots and streaks. Antennae brown.

Head hirsute, the vertex more sparsely so than the frontal region.

Lingual lamellae of gnathochilarium widest anteriorly, incurved posteriorly, posterior arms a little divergent, three times as long as greatest width. Stipites five and a half or more times as long as the greatest width. Spatula conspicuous, distally subtriangular. Mentum one-half as long as greatest width.

Eye areas subtriangular, but with the sides convex; ocelli about 22, in five curved series, counting from outermost mesad as follows: 5,5,5,4,3.

Antennae very long, proportions as represented in Pl. XXXIII, fig. 2. Length 4.2 mm.

A fine median longitudinal keel over all segments excepting the last. Carinae increasing in size from the first caudad. Inner setae becoming relatively farther and farther from middle line in going caudad, these setae inserted in a wide longitudinal depression extending along each side, the dorsum between the depression a little convexly elevated. Setae, as usual, becoming directed more and more strongly caudad in proceeding from anterior to posterior segments.

First segment of the usual form, the anterior margin broadly extended cephalad mesally and fitting into excavation of head, the lateral portions of margin a little incurved. Carinae small, continuous with anterior margin of plate. Innermost bristle about one-third the distance from median to the edge of the carina of the corresponding side, in transverse line with the more anterior of the lateral bristles which is situated cephalad and considerably mesad from the posterior one, the latter close to the caudal margin. Segment considerably depressed or furrowed transversely, the inner setae located in this depression. Setae erect.

Anal scutum truncate caudad, the posterior margin weakly incurved.

Anal valves not equalling the scutum, widely rounded and broadly margined. The three bristles nearly equidistant, the most ventral three or more times as far from the ventral scale as the most dorsal is from the scutum.

Anal scale sub-trapezoidal, the lateral and cephalic margins weakly convexly rounded, the caudal distinctly incurved between the two long bristles.

Appendages of second segment of female conspicuous, strongly enlarged distad, the distal end with long bristles. A sub-lobe sheathing the cephalic surface of main appendage, this bearing long bristles apically. See Pl. XXXIII, fig. 7.

Locality—Colorado (T. D. A. Cockerell).

Tingupa gen. nov.

Antennae moderate, strongly clavate distally, the fifth article longest and much thickest, the third article second in length.

Eyes well developed, consisting of numerous ocelli (8-20) arranged subseriately.

Gnathochilarium with promentum well developed, triangular and moderately low.

Segments convexly arched dorsally and with well-developed carinae; dorsum covered with densely arranged, laterally compressed and in part conically pointed granules which extend to edges of carinae and on caudal segments may project as spinous processes from carinae and caudal margin of segments; setae moderate to long, clavate.

Segments in adult 30.

Type—*Tingupa utahensis* sp. nov.

Distribution—Two species known, the type from Utah and a second form, *Tingupa monterea,* from California.

The genus seems to have closest affinities with *Pseudotremia.*

Tingupa utahensis sp. nov.

General color brown, like that of the dead leaves among which it lives; in some with finer mottlings of paler color on sides. Venter pale. Legs from yellow or almost white to pale brown. Antennae brown, the articles often paler at distal ends.

Segments with major subdivision strongly granulate, the granules or scales mostly somewhat compressed laterally or elongate antero-posteriorly and closely arranged; similar but narrower elevations closely covering the dorsal portion of the minor subsegments; scales larger on posterior segments, series of larger ones with conical apices directed caudad as acute spinous projections. Segments mesally well arched, depressed immediately mesad of the carinae; entire dorsum weakly longitudinally furrowed, the furrow divided by a fine, at times almost obsolete keel. Segments bent cephalad laterally, the latero-cephalic margin widely rounded, the acute anterior angles situated close to body. Edges of carinae often appearing finely crenate or dentate from the presence of the projecting tubercles. All setae clavate, in proceeding from first to posterior segments the two lateral setae on each side become more extended in these directions, more strongly directed caudad and cephalad respectively, in some being horizontally extended in these directions.

Vertex of head crossed by a low, rounded, median longitudinal ridge; head also elevated along a line connecting the angles of the eyes; transversely depressed between bases of antennae; conspicuously and rather densely hirsute with moderately long stiff and erect hairs or setae.

Gnathochilarium with lingual lamellae inclusive of processes three and a fourth times as long as the greatest width. Stipites in length about 4.7 or a little less times the greatest width. Promentum moderate, triangular in general outline, the basal margin broadly angularly

excised. Mentum with distal border broadly angular, fitting into excision of promentum; greatest width apparently about three and a half times the mesal length, but the position of the sclerite and some difficulty in determining the proximal limit leaves room for some uncertainty.

Ocelli arranged in a narrowly sub-triangular patch, the apex directed mesad and toward that of the opposite eye; caudal margin shortest, a little convex, the dorsal margin convex near caudal margin and concave near apex or mesal angle, the ventral margin concave. Ocelli in four series, counting from ventral row dorsad as follows: 7, 6, 4, 3, giving all together 20 or thereabouts.

Antennae strongly clavate, the fifth article longest and thickest, the first three especially much more slender.

First segment clearly longer than the second, the cephalic margin mesally protruding, the lateral portions straight or but little concave. Caudal margin nearly straight, distinctly excised immediately mesad of carinal corners, the latter angularly projecting caudad or latero-caudad, the posterior of the two lateral bristles projecting caudo-dorsad and somewhat laterad from bottom of this excision. Depressed or widely furrowed longitudinally on each side between median line and the lateral margin, the anterior of the lateral bristles springing from the cephalic portion of its depression in a dorso-cephalic direction. The innermost bristle near cephalic margin and well toward the median, extending dorso-cephalad.

Anal scutum in outline as viewed from above somewhat trapezoidal, the lateral margins not strongly converging; caudad widely sub-truncate, the lateral angles somewhat rounded. Papilla on each side nearly midway between the median line and the lateral margin, bearing a long curved bristle. A pair of long bristles borne on weak elevations each side of the median line and half-way between caudal and cephalic limits; and each lateral margin with a long bristle arising from near anterior angle and a weak tooth or acute obtuse bristle midway between anterior and posterior ends.

Anal valves with caudo-dorsal angle sub-acute, apically but weakly rounded, the caudo-ventral angle obtuse. Each valve bearing three long bristles, a little within the ventro-caudal margin, these bristles projecting caudad, the most ventrad being at the obtuse caudo-ventral angle or extension and closer to dorsal scutum than to anterior end of free margin, the other two equidistant from this one, with the upper one closer to scutum than to median bristle.

Ventral scale bearing two long, caudally directed bristles.

Anterior pairs of legs, in female at least, with distal joint bearing beneath a conspicuous comb-like series of stout bristles. See Pl. XXXIII, fig. 8.

Appendages of second segment large and distinct. Two sub-cylindrical processes springing from a main plate or fold and extending ventro-cephalad, these processes translucent or transparent distally. See Pl. XXXIII, fig. 7.

Length 7–8 mm.

Locality—Mill Creek Canyon, Utah.

Found among dead leaves along the margin of a deeply shaded ditch on south side of canyon, the accumulation of leaves remaining very damp.

Tingupa monterea sp. nov.

Dorsum dark brown, a row of light spots along each lateral margin, a spot being on edge of each carina, and two other rows, more or less evident, between this row and a pale median longitudinal line, the inmost row being close to the latter. Venter pale. Feet white or yellowish. Vertex of head dark brown, the other portions paler, yellowish. Antennae brown, the articles pale distally.

Segments bent first forward laterally and then again somewhat caudad distally, especially in case of the posterior segments, the lateral margins lying parallel with axis of body and not widely rounded or curved in mesad, the cephalo-lateral angles being in fact farther from the body than the caudal in most segments; a little incurved mesad of each caudo-lateral angle, but less conspicuously so than in utahensis. Segmtnts, excepting first and last, with a fine longitudinal keel along mesal line. Carinae strongly developed and conspicuously extended laterad and meeting together rather closely; finely denticulate. Granules or scales covering the segments densely in compact rows, their conical apices projecting like minute spines, at times giving the appearance of hirsuteness when viewed parallel to surface of segment, the whole surface thus appearing finely spinescent. Setae long and clavate, situated nearly as in utahensis.

Anterior margin of first segment bow-shaped, being mesally moderately curved cephalad or convex, then each side concave, and lateraly again convex. Not mesally furrowed or keeled.

Anal segment as viewed from above with the sides strongly converging caudad, incurved; widely truncate caudad; a large mesal tubercle or elevation a little cephalad of caudal margin.

Anal valves appearing a little to exceed the scutum. Dorso-caudal angle widely rounded, the free margin first curving evenly ventrad and cephalad and then running straight cephalad parallel with the dorsal margin. Dorsal and ventral edges elevate, the caudal not so.

Head with vertex elevate, somewhat longitudinally rugose along caudal border. Conspicuously depressed on each side from base of antenna caudad, the antenna being inserted in anterior end of the furrow. Head densely hirsute with short setose hairs over entire surface, sometimes appearing a little sparser on vertex.

Eye area small; the ocelli numbering eight or thereabouts, arranged in three series, counting from above toward antenna, 3, 3, 2; the side of patch toward median and that toward dorsal surface subequal, each consisting of three ocelli, and the two lying at right angles to each other or nearly so.

Antennae short, strongly clavate, the fifth article decidedly longer and very much thicker than the third.

Gnathochilarium with lingual lamellae, inclusive of processes, about 3.8 times as long as the greatest width which is anteriorly. Stipites inclusive of processes, about 4.25 times as long as the greatest width. Greatest width of mentum apparently three times the length, though the caudal margin was made out with some uncertainty. Promentum distinct and well developed. Spathula evident. Stili not detected.

Size approximately that of T. utahensis.

Locality—Pacific Grove, California (June, 1902.)

Caseya irritans sp. nov.

General color in alcohol light brown; indications of pale, whitish transverse bands, one across each segment, and of a row of whitish spots laterally. Venter and the feet yellowish. Head with the vertex pale, finely areolated in brown; frontal region brown, a distinct pale spot ventro-mesad of each antenna, the spot transversely elongate, and a median pale spot immediately dorsad of the inner ends of these two spots; clypeal region pale; labrum yellow.

Head widely excavated caudad. Vertex transversely elevated, smooth and shining in the specimen as at present, crossed by a faintly developed fine median longitudinal line. Frontal and clypeal region of head sub-complanate; a conspicuous transverse impression above clypeus, indented or bent dorsad mesally.

Eye patch elongated in a meso-ventral direction. Ocelli strongly developed, 13 in number and arranged in three series, which, counting from above toward antennae are as follows: 7, 5, 1; on one side the series appearing rather as four, 1, 6, 5, 1.

Antennae long and slender, scarcely clavate. The third article much longer than the fifth; the seventh much smaller than the sixth, being but little more than half its length.

Promentum moderately large, triangular; mentum a little less than three times as wide as the median length. Length of lingual lamellae, inclusive of processes, a little less than three times as large as the greatest width, which is caudad of the middle. Stipites, inclusive of processes, about 4.4 times as long as the greatest width. Sensory cones of outer process of stipes 5 or 6 in number, of inner process apparently 6. Stili not detected.

First dorsal scutum sub-reniform, the anterior median portion rather narrowly protruding. Caudal margin with lateral angles evenly rounded, the median portion almost straight, slightly obtusely indented at mesal line. A fine median longitudinal line impressed across caudal portion of plate. Lateral regions of segment marked with numerous fine oblique striae, there being similar striae on the anterior rounded median portion but these extending but little caudad.

Body fusiform, attenuated both caudad and cephalad.

Segments caudad of the first with numerous striae over sides beneath; on the second there are three striae above the obsolete shoulder-like bulging occurring where carina would usually be developed, on the

third four or five, the striae existing farther and farther dorsad on subsequent segments, from the fifth caudad extending completely across the dorsum. From the fifth segment to the ultimate a band-like area across dorsum marked apparently with coarser striae and distinctly delimited laterally; on the more caudal segments the band extending caudad a little beyond the usual limit of segments and presenting weak crenations or dentations, the band farther cephalad on segment in median and anterior region of body.

Anal scutum in outline as seen from above with sides converging caudad, nearly straight or but little incurved mesally; caudal margin mesally emarginate. Two impressions extending from anterior margin on each side of the middle and converging to meet in an acute angle at a mesal point on the caudal emargination of plate. Papillae slender, gradually acuminate.

Each anal valve crossed longitudinally over dorsal portion by two or three striations. The caudo-ventral edge nearly straight, margined.

Length, 10 mm. Greatest width 1.5 mm.

Locality—Portland, Oregon (Aug., 1902). One female.

FAMILY STRIARIIDAE.

Striaria nazinta sp. nov.

Body uniform light brown in color. Legs yellow. Antennae white.

Body cylindrical, gradually attenuated cephalad as well as caudad.

First segment large, expanded on each side in a plate which extends cephalad over lateral portion of head. Mesally the front margin is straight or nearly so. Anterior border with a ridge-like elevation continuous laterally with edges of the lateral plates, the two ridges meeting in a mesal elevation and at an angle open cephalad, the surface of plate in front of this elevation obliquely descending to head, closely tuberculate. On main area of plate each side of the median line are six strongly elevated and relatively thin carinae of which the one nearest the meson is lower and begins farther cephalad than the next laterad; the farthest laterad of these carinae is much lower and shorter than any other and is the only one not attaining or nearly attaining the caudal margin. Laterad and cephalad of the carinae and to the very edges of the lateral plates, the segment is densely tuberculate. Between the carinae the granules are irregularly scattered, and relatively few, not in definite rows, though they may usually be regarded as representing two broken series in each interspace.

Second segment with twelve dorsal and dorso-lateral carinae in addition to the major lateral carinae, but crossing the entire width of the major sub-segment and, as on all subsequent segments, more strongly elevated at caudal ends. Lateral carinae or plates less strongly extended horizontally than the lateral plates of first but in general similar, the lateral portions less strongly granulate.

Third and subsequent segments with twelve dorsal and lateral carinae in addition to the lowermost pair, the latter not at all carried

out on horizontal plates or extensions like those of first two segments but reduced and comparable in size to the one immediately dorsad of it, and projecting cephalad instead of caudad as do the other carinae. These segments with only scattered and weakly developed granules, some appearing almost smooth. All marked with the usual fine median keel.

Anal scutum conspicuously granulate with strongly developed tubercles.

Anal valves not equalling the last dorsal scutum, narrow and elongate. Granulate with strongly developed tubercles similarly to the anal scutum.

Caudal margin of head straight, not at all excavated. Vertex of head transversely elevated, the lateral portions ridge-like, the ends abrupt and conspicuous, while the mesal portion of the elevation extends ventrad and narrows to a mesal point attaining the imaginary line connecting the bases of the antennae, in front of which extension the level is depressed. Vertex crossed by a narrow median longitudinal furrow. Entire head granulate, the lateral portions more coarsely so. Hirsute, more strongly so over clypeus and adjacent region.

Labrum set off by a transverse depression or furrow; lateral portions rounded; mesally with two conical teeth.

At each lateral end of transverse elevation of the vertex a small darkened area apparently representing an eye; but in the type specimen ocelli indistinct, three or four obscurely indicated areas apparently representing them, the granular character of the general surface making their certain identification difficult.

Antennae short; strongly clavate; appressed close to head and inconspicuous. Fifth segment longer and much stouter than the third; the seventh smaller than the sixth. Subdensely hirsute with short stiff hairs, the proximal articles rather more sparsely clothed.

First legs bearing along the cephalo-ventral surface a calamistrum-like row of stout setae, elsewhere with fine hairs which are more sparse on proximal joints. A moderate tuberculate elevation toward distal end of femur on ventral surface like those present in males of some craspedosomatids.

Other legs mostly but sparsely provided with hair; all tuberculate.

Length, 13 mm. Width, 1.2 mm., nearly.

Locality—Portland, Oregon (Aug. 1902). One female specimen.

FAMILY XYSTODESMIDAE.

Fontaria tuobita sp. nov.

Black, the carinal and lateral margins narrowly bordered with pale. Anterior portion of prozonites yellowish. Sometimes the black of the dorsum is in varying degrees supplanted with brown which encroaches in irregular streaks and spots. Sides paler, smoky yellow, the dark color more pronounced adjacent to bases of legs and on caudal segments or forming distinct bands down each segment in alternation

with the bands of yellow of the prozonites. Venter pale. Legs yellow. Vertex and frontal region of head dark, a background of yellow being closely covered with a network of black; clypeal and labial region yellow.

Head with median furrow of vertex sharply impressed, extending to an imaginary line tangent to the dorsal edges of the bases of antennae where it touches the mesal angle of an impression extending between antennae. Finely hirsute.

Antennae slender, rather short.

First dorsal plate a little narrower than the second. The lateral and cephalic margins together forming an even semicircular curve; caudal margins of carinae oblique, the intervening caudal margin of segment nearly straight. Mostly smooth and shining, finely rugose along cephalo-lateral border.

Dorsum well arched, the carinae somewhat depressed below the horizontal. Second segment with cephalo-lateral and caudo-lateral angles a little larger than rectangular, narrowly rounded. In subsequent segments the cephalic border adjacent to cephalo-lateral angles becomes more and more protruded cephalad, and the caudo-lateral angles become more and more produced caudad in an acute angle or process.

Anal scutum terminating in a cylindrical process which is curved ventrad and is truncate distally.

Anal valves strongly raised along free mesal margins.

Anal scale triangular, the lateral margins convex proximally, elsewhere nearly straight; caudal angle narrowly extended a little and rounded.

Ventral scuta transversely impressed, more strongly so on caudal segments; a little extended at a small elevation or process at base of each leg.

Gonopods of male with the coxae relatively large and stout, distad of this extending ventro-cephalad; narrowed distad and terminating in a blunt pointed process which curves mesad and a little ventrad and then toward apex bending back proximad. On the ventro-mesal surface at one-third the length from coxae, an acutely-pointed, blade-like process, which curving meso-ventrad and then distad crosses its fellow in the middle line. See further, Pl. XXXV, figs. 7 and 8.

Length, 19 mm. Width 4.5 mm.

Locality—Cloudcroft, Sacramento Mountains, New Mexico (Sept. T. D. A. Cockerell).

FAMILY POLYDESMIDAE.

Scytonotus piger sp. nov.

Dorsum dark, sometimes of reddish caste. Venter but slightly or not at all paler than the dorsum. Legs uniform brown or yellow. Head and antennae dark brown.

Head roughened. Vertex crossed by a short median longitudinal impressed line. Hirsute with short stiff bristles which are rather uniformly arranged.

Antennae clavate. Moderately to sub-sparsely clothed with mostly short hairs.

First dorsal plate less in width than either head or second dorsal scutum but relatively wider than in granulatus. Somewhat semicircular in outline but at each side extended into a narrow carina which is dentate, there being commonly two major teeth of which the caudal has a minor or secondary denticle on its posterior edge and in front of the anterior of which are several small denticles. Front margin mesally sub-straight, laterally convexly rounded.

Depressed along the cephalic margin, the depression extending caudad mesally and narrowing to a furrow which again expands triangularly adjacent to the caudal margin. The segment elsewhere elevated. Densely covered with tubercles, the setae much as in granulatus.

Second segment with the lateral ends curved cephalad and embracing the first. Segment longer laterally than mesally. Bearing three transverse rows of large tubercles. Carinae with cephalic angles acute but caudally widely rounded; laterally showing eight or nine rather small crenulations, the incision between them shallow; no translucent margin such as is present in granulatus.

Subsequent segments gradually increasing in length and showing from three to five or six transverse rows of tubercles. Posterior angles of carinae becoming less widely rounded and extending farther and more acutely caudad, in the last few segments being a little produced. Lateral margins of carinae with small crenulations or teeth which for the most part are well rounded and not at all acute; teeth or crenulations numbering from eight to ten or twelve, the lesser number occurring on the spiraculiferous segments. Prozonites very finely and densely granulate.

Anal plate convexly elevated proximally, bearing separated rows of conically pointed tubercles; two tubercles projecting laterad at base or proximal end of the cylindrical apical portion of scutum, this portion being slightly depressed ventrad and apically rounded and bearing on caudal surface four setigerous tubercles.

Anal valves with mesal and caudal margins elevated and smooth. In some an irregularly oblong area over posterior portion of each valve roughened with sharply separated depressed areolae. A setigerous tubercle in furrow near caudo-mesal angle and a second similar one near middle of plate nearer mesal than dorsal margin.

Anal scale with caudal extension convexly rounded and bearing two setigerous tubercles. Lateral portions in outline something like that of the fore part of a shoe.

Length 12–13 mm. Width ad 2 mm.

Locality—Upper branches of Mill Creek Canyon, Utah.

A number of specimens were obtained about springs in upper side branches of the canyon. It seems to be close to *S. granulatus* though clearly distinguishable in numerous details.

Polydesmus (**Kepolydesmus** subgen. nov.) **anderisus** sp. nov.

Brown to dark reddish brown; carinae along lateral edges and above of lighter color, often yellowish, the pale bands commonly more distinct caudad and frequently extending mesad along the caudal margin of each segment; often some of the anterior segments are dorsally distinctly areolated with black, which may form a more solid transverse band along the cephalic margin excepting its lateral ends. Venter pale. Legs yellow or light brown. Head brown, a dark blackish band between the bases of the antennae, this band concavely excised on ventral side; labral region yellowish. Antennae darker than the legs, being concolorous with the dorsum of body.

Vertex of head crossed mesally with a sharply impressed, distinct longitudinal furrow. Vertex and frontal region sub-sparsely clothed with short setose hairs, the clypeal region more sparsely provided with longer hairs.

Antennae long; a little clavately enlarged distad.

Body gradually narrowed cephalad from about the twelfth segment, less strongly so caudad.

First dorsal plate scarcely narrower than the head inclusive of genae, its greatest width about 2.3 times the mesal length. Anterior margin mesally straight or nearly so, the lateral angles widely rounded. Caudal margin slightly and widely mesally incurved, laterally extending gradually cephalad to meet the lateral margin at a rounded angle. Entire border of margins depressed. A transverse impression caudad of the cephalic border, a broad median longitudinal depression extending from this to the depressed border along the caudal margin. The rows of minute setigerous granules distinct, somewhat uneven; but the main tubercles very obscure or not at all indicated. Segment finely roughened laterally. Each lateral margin with a single minute denticulation.

Second segment bent cephalad on each side. Antero-lateral corner sub-rectangular as is also the cauda-lateral, but the latter well rounded. Sharply margined laterally, caudally and also along lateral portions cephalically. Lateral margin of carina with one distinct denticle at antero-lateral angle and one or two faint or obsolete crenulations or denticles indicated farther caudad.

Third segment nearly as the second; but the anterior margin immediately mesad of the cephalo-lateral angle more rounded and with a small indentation.

From the second segment caudad the cephalo-lateral angle becomes more and more rounded and the caudo-lateral less and less so, the latter finally becoming somewhat produced though not acute. The produced caudo-lateral angle of the penult segment somewhat indented caudally. Segments dorsally depressed mesad of the carinae, the depression anteriorly bending obliquely cephalo-mesad. Carinae bent a little dorsad. Transverse furrow deep and distinct, extending across dorsum about half way from meson to each lateral margin. Tubercles not sharply delimited, but rather more distinct on caudal segments.

Anal scutum with four denticulations along each lateral margin, each of these teeth bearing a stout seta. Dorsal surface with transverse rows of setae. Caudal process of the scutum straight, bearing four long, finely pointed setae.

Ventral plates impressed with the usual transverse furrow and with a less distinct longitudinal one. Smooth except for a moderate clothing of hair.

Legs rather long and slender, the second article inflated.

In the male the first two pairs of legs are conspicuously smaller and the ultimate joint is clothed within with stout setae subseriately arranged, the row being more even and well marked on the second. Other legs on inner surface with rows of setigerous tubercles, the setae being short, otherwise with sparse short hair only, except on the proximal articles. Second legs showing a cone-shaped, apically truncate process on the ventral surface of coxa.

For structure of copulatory appendages of the male see Pl. XXXVII, figs. 2, 3, and 4.

Length of female, .26 mm. Width, 3 mm. Length of antennae ad 3.8 mm.

Locality—Kendrick, Idaho (W. M. Mann).

Polydesmus (**Kepolydesmus** subgen. nov.) **sontus** sp. nov.

Dorsum deep brown to almost black, the prozonites mostly paler; carinae yellow. Pleural region between carinae and the bases of the legs brown. First segment commonly darker than the adjacent ones, often black, the caudal and carinal borders and the minute setigerous granules yellowish. Venter and legs yellow. Head with the vertex dark brown to blackish, the dark area extending forward between the antennae as a narrow, median tongue-like band, the color commonly deeper at the base or proximal end of this band; sides of head dark, a yellow band between dark area of vertex and the sides extending obliquely forward over insertions of antennae to the yellow lower frontal and clypeal area. Antennae yellow to brown, the sixth and seventh articles commonly conspicuously darker, the seventh being black and the sixth dark brown to black.

Body gradually attenuated cephalad; over posterior portion with the sides subparallel excepting for the few last segments which are narrowed in the usual way.

Vertex of the head crossed longitudinally by a fine median impressed line which extends almost to an imaginary line tangent to the upper edges of the antennal sockets. Frontal and clypeal region clothed with setose hairs of moderate length, the vertex appearing glabrous or nearly so.

Antennae short, a little less than or at most equalling the width of the body. Scarcely clavate. Sub-sparsely hirsute, the hairs more dense on the flexed side.

First dorsal plate in outline semi-circular or half-moon shaped, but the caudal margin a little incurved. Wider than the head inclu-

sive of the genae. Anterior border margined. Carinae narrow; bent dorsad; lateral margin with a single emargination but with no real denticulation. Crossed by a fine median longitudinal line.

Second segment bent forward at the sides. The anterior angles of the carinae sub-rectangular, somewhat rounded, overlapped by the first plate. A small denticulation on outer side of the cephalo-lateral angle and two weak or obsolescent emarginations indicated farther caudad. Caudo-lateral angles not rounded, a little obtuse. Caudal margin of carina excavated or abruptly bending meso-cephalad. Carinae rather narrow, bent somewhat dorsad. Inter-carinal region of dorsum strongly elevated and convex as it is on subsequent segments.

Lateral margin of carina of third segment shorter than that of the second. Anterior angle rounded, the emargination caudad of it as on the second segment, the denticle in front of the emargination likewise low and rounded. Posterior angle rectangular or acute. Caudal margin of carina straight, extending cephalo-mesad without showing any curvature.

Fourth segment similar to the third but the lateral carinal margin longer, sub-equal to that of the first, and the caudal angle rectangular or slightly obtuse. Only the single anterior emargination indicated.

Fifth segment abruptly longer. Lateral carinal margin bulging laterad, being mesally very obtusely angular. Caudal angle obtuse and rounded. The anterior emargination very weak.

Sixth segment a little longer than the fifth, the lateral carinal margin but weakly and evenly convex. The emargination very faint.

Subsequent segments sub-similar but the emarginations not at all manifest. The caudal angles in proceeding caudad become more and more acute and finally extended or produced sharply. All but a few of the segments with the dorsal transverse sulcus sharply impressed and extending well toward the carinae where it becomes more indistinct. A median longitudinal impression which is distinct in front of the transverse sulcus which is mostly vague or absent caudad of it.

Anal scutum with the process truncate and apically the caudal end shallowly emarginate.

Anal valves with the caudal margin a little incurved, meeting the mesal margin at an acute but rounded angle. Mesal margin elevate. A short curved impression near the mesal margin of each valve and about the middle of its length, the concave side being mesad. A longer and also slightly curved impression toward dorsal margin, the concavity being dorsad or ectad.

Anal scale relatively long, the caudal border emarginate. Laterally weakly emarginate at proximal ends of sides.

Ventral plates with a longitudinal median impression which is distinct on the posterior segments but is indistinct or not at all evident cephalad. Transverse impression mostly very weak. All rather densely clothed with hair, some of which is conspicuously long.

Legs sparsely clothed with short stiff hairs which are most abundant on distal joints and on the ventral or inner side.

In the male the first legs are, as usual, small, but the second are not conspicuously reduced. The bristles on the ventral surface of the distal joint of first legs more densely and sub-seriately arranged than on the others.

Copulatory appendages of the male moderately small, strongly bent cephalad and parallel with the body. The main outer process of each side bearing distally three chitinous appendages. The most proximal of these is short and blade-like and extends dorso-mesad and a little cephalad, crossing with its mate at the middle line. The second takes its origin cephalad and dorsad of the first and as a long, conspicuous, flattened and somewhat twisted blade extends first cephalad and then curves ventro-mesad. The third takes its origin a little dorsad from the base of the second and curves first dorso-mesad and then ventro-mesad, the distal portion curving finally ectad again and ending in a slender acute point. From the ventral concavity of this appendage springs a slender process which bears distally a stout curved seta which extends caudad to end in the neighborhood of the first process. See further Pl. XXXVIII, figs. 2 and 3.

Length 19-20 mm. Width 2.5 to 2.7 mm. Antennae ad 2.5 to 2.7 mm.

Locality—Los Angeles, Cal. (June, 1909.)

Polydesmus amandus sp. nov.

Segments with the main dorsal divisions whitish, a tendency for the median area contiguous to the cephalic margin to be brown, the ultimate segments and a few of the most anterior commonly more or less completely brown; the prozonites clear brown. First dorsal plate clear brown. Venter white, excepting a few of the most caudal and of the most anterior segments which are brown. Legs white but with the coxae all brown and with a decided tendency for the distal articles likewise to be brown or brownish. Head uniform brown, the color being of a lighter shade than that of the first segment. Antennae uniform brown or with some of the median articles whitish in whole or in part.

Head nearly smooth, the vertex crossed longitudinally by a short median impressed line. Clothed rather densely over nearly the entire surface with very short hairs.

Antennae a little longer than the body is wide. Clavate, the sixth article being considerably the thickest.

First dorsal plate narrower than the head inclusive of genae and than the second segment. Transversely sub-elliptical. Lateral carinal margin with three teeth; a fourth tooth projecting from edge on the cephalo-lateral curve. Tubercles in numerous rows; strongly developed; apically acuminate and setigerous. The setae curved or frequently hooked distally. A transverse impression or sulcus cephalad of the row of tubercles along caudal border.

Second segment strongly bent cephalad at the sides. On the carinal margin immediately caudad of the acute denticle of the cephalo-lateral angle is a more obtuse one and caudad of this five larger, low

crenations which are continuous as a series with a row of crenations or projecting tubercles along the caudal margin; all are setigerous. Tubercles all strongly developed. Carinae sub-horizontal.

Carinal margin of the third segment rather longer than that of the second but similarly sculptured.

Subsequent segments becoming longer, the rows of tubercles they bear more numerous, the carinal crenulations weaker, and the caudo-lateral angles more rounded excepting in the last few where they tend toward rectangular. In the antepenult segment alone are the caudo-lateral angles a little produced. A transverse sulcus between the second and third or the third and fourth rows of tubercles from the caudal margin. Two longitudinal impressions, one a little each side of the median, extending from cephalic margin a short distance caudad and then curving out laterad. Wide spaces intervening between the carinae of adjacent segments.

Anal scutum bearing transverse rows of strongly developed, conical setigerous tubercles like those of other segments, these rows well separated from each other. Apical process of scutum decurved, conical, not truncate, and bearing long setae as usual.

Anal valves with the dorsal and mesal margins sub-parallel, the caudal margin meeting the mesal in a rounded but as a whole somewhat acute angle. A little cephalad of the caudo-mesal angles is a transverse impression crossing the median line from valve to valve. Mesal margins strongly elevated. A conspicuous conical and setigerous elevation near the middle of each valve, this elevation closer to the mesal than to the dorsal margin.

Anal scale with each half in outline like that of shoe with high instep. Caudal margin crenately incised a little mesad of each caudo-lateral angle, the crenulation adjacent to each angle bearing a long seta.

Ventral plates pilose. The transverse impression in most more strongly developed than the longitudinal.

Legs rather long, very sparsely hirsute proximally but more densely so distally. Second and third articles inflated dorsally.

The first legs reduced as usual, the second intermediate in size.

Gonopods of male of moderate size. Each one presenting two main chitionous processes of which the cephalo-mesal one is apically bidentate and presents near its base an acute conical tooth projecting in a cephalo-mesal direction. The second process lies against the first for most of its length but distally diverges from it, extending more directly ventrad and ending in an acute point. See further Pl. XXXVIII, fig. 6 and Pl. XXXIX, fig. 1.

Length of male 18 mm. Width 1.9 mm. Length of antennae 2+ mm.

Locality—Mill Creek Canyon, Salt Lake Co., Utah. (Sept., 1900).

Polydesmus sastianus sp. nov.

Dorsum brown; the carinae paler, yellowish. Sides pale brown. Venter and legs yellow. Head light brown. Antennae light proximally, the distal joints brown.

Head finely roughened. The vertex crossed with the usual impressed line. Clothed rather densely with very fine short hairs.

Antennae short. Clavately thickened. Distal articles sub-densely clothed with moderately short hair; but with only a few hairs on the first and especially on the second articles. The four sense cones conspicuous.

First dorsal scutum narrower than the head and also distinctly narrower than the second segment. Transversely sub-elliptical with the caudal margin, however, but little convex. Tubercles strongly developed, conical, in crowded series. The setae conspicuous, those of the rows of tubercles along cephalic and caudal margins very long and, as usual, curved or hooked distally.

Second segment not strongly bent forward laterally. The conical tubercles strongly developed and densely arranged as on the first one. Carinal margin with the anterior and the posterior angles about equally rounded; laterally with six, large, angular, setigerous teeth, of which the most cephalic, which is located on mesal side of cephalo-lateral angle is smallest and most acute, the fourth and fifth with a secondary indentation on their cephalic edge and three similar teeth on caudal side. The series of teeth continued along the caudal edge of plate by a row of large projecting tubercles.

Third and fourth segments with their lateral margin shorter than that of the second; the caudo-lateral angle of carina more rounded; lateral margin with same number of teeth as the second.

On the subsequent segments the caudo-lateral corners of the carinae become more angular, first becoming sub-rectangular and then on the last two preceding the anal plate a little produced caudad. Entire dorsum with a longitudinal median keel-like elevation which is better developed on the prozonites. Transverse sulci rather weak.

Anal scutum strongly tuberculate, the tubercles conical and setigerous like those of the preceding segments. Caudal process narrowly rounded.

Anal valves somewhat as in the preceding form.

Anal scale sub-triangular. Caudal angle a little rounded. Seven pairs of setigerous tubercles along the lateral margins.

Most of the ventral plates are very distinctly marked both with the transverse and with the longitudinal impressions; of these impressions the longitudinal one is narrower and usually appears more sharply impressed.

Legs moderately clothed with rather short hair, the first two joints more sparsely so.

Length: 10–11 mm. Width 1.5 mm. Length of antenna ad 1.5–1.6 mm.

Locality—Shasta Springs, Cal. (Aug., 1909.)

Three specimens were secured, one adult female and two not fully grown males.

Polydesmus socarnius sp. nov.

Dorsum brown; the carinae commonly paler; a median longitudinal dark line indicated in some, this more distinct caudad. Venter scarcely paler than dorsum. Legs yellow or light brown. Head brown, the genae and the clypeal and labial region paler, yellowish. Antennae brown, darker than the legs, but light distally.

Vertex of head crossed by the usual median longitudinal impressed line, this line extending to the angle between two furrow-like impressions which extend from the median ventro-laterad to the bases of the antennae. Head conspicuously longitudinally furrowed along each side in line with the antenna, the latter being inserted in the furrow. Somewhat finely rugose over vertex. Moderately pubescent with rather short hairs.

Antennae a little longer than the width of the body, clavate to the sixth joint, seventh article comparatively large, showing the usual sense cones distinctly. Clothed densely with mostly short hairs.

First segment wider than the head without the genae but distinctly narrower than the head inclusive of the genae and than the second segment. Transversely somewhat elliptical; the cephalic margin widely and but weakly convex; cephalo-lateral angles strongly rounded, the margin evenly curving to the middle of the lateral carinal edge where it ends on each side in the single obtusely angular tooth. Caudo-lateral corners of the carina sub-rectangular, the caudal margin of the carina being nearly straight, untoothed. A row of four contiguous tubercles adjacent to the caudal margin along its median portion. The median convex area of segment with tubercles weakly or but obscurely indicated.

Second segment bent cephalad laterally as usual; overlapped by the first plate. Lateral carinal margin with three strongly developed teeth of which the cephalic is most acute and of which the most posterior is at or but little caudad of the middle of the margin, the latter caudad of this tooth being straight or but little curved to the sub-rectangular caudo-lateral angle. Posterior edge of carina straight and untoothed. Three rows of tubercles which are not closely placed, the two first rows extending from carina to carina; the row along the caudal border consisting of six elongate and roundly conical tubercles, which project a little beyond the caudal margin and are widely separated from each other, the two more median ones being closer to each other than are any other two.

In the following segments a fourth tooth, at first ventral in position, occurs between the caudal angle and the median tooth of the carinal margin. The caudo-lateral angle becomes gradually more and more acute and extended caudad, on most of the segments being conspicuously produced. Most of the segments typically with a narrow longitudinal furrow adjacent to the carinal margin, a little mesad of this with a wider and deeper furrow and again a little farther mesad a second narrow furrow, there being between the large and more evident furrow and the narrower one each side of it a carina-like elevation which

is commonly rather conspicuous. Dorsum as a whole complanate. Carinae a little elevate dorsad.

Anal plate with distal process apically decurved.

Anal valves with the mesal edges strongly margined and elevated. The usual setae present.

Anal scale sub-triangular.

Ventral plates with the usual cruciform impression, the transverse furrow being the wider and deeper in most plates.

Legs clothed with short stiff hairs, this rather longer and more abundant on distal joints.

Length, 10–11 mm. Width, 1.3–1.4 mm. Length of antenna ad 1.6 mm.

Locality—Salt Lake City, Utah (June 23, 1900).

FAMILY PARAIULIDAE.

Paraiulus zakiwanus sp. nov.

Color brownish red. The first segment clear reddish without darker markings; but most of the body subsequent to this with a row of black dots along each side, one to each segment, which on the more posterior segments is supplemented with an area of smoky or blackish which tends to extend or diffuse about the segment and thus much to darken it. No distinct median dorsal line and no light spots. Vertex of the head dark, a band between the eyes darkest, black; the head elsewhere reddish, the red intruding into lower border of the dark area in three semicircular incisions. Legs brown.

A sharply impressed furrow extending from the upper margin of the eye area mesad curving evenly mesad and then bending sharply back dorsad to meet its fellow at an angle on the mesal line; the median longitudinal line extending distinctly to this angle. A second impressed line a little cephalad of the caudal margin of the head, this line being bent forward at a sharp angle mesally. Head very finely rugose.

Eyes are large, sub-triangular, the ventro-lateral side and the caudal side convex, the mesal being concave. Ocelli 63-65, arranged in nine transverse series which, counting from above ventrad are as follows: 11, 10, 9, 9 (8), 7, 6, 5, 5 (4), 3.

First dorsal plate with the lateral margins not angularly produced beneath but nearly straight and subparallel with the axis of the body. Entire border of plate distinctly margined. Finely rugose or nearly smooth, not at all striate.

Second segment with four deep striae on each side beneath and on caudal division, the lowermost margining the lower edge.

Subsequent segments also deeply striate beneath, the striae well spaced apart.

Spiracles rather small; touching the transverse suture which is bent at their level.

In the male the sixth and seventh segments are moderately extended beneath the lower margin of the latter evenly convex in outline, not at all angular.

First legs of male strongly enlarged as usual. Uncinate. Inner surface covered with rounded tubercles which are arranged in transverse rows as shown in Pl. XL, fig. 4.

Second legs of the male with the coxae much enlarged in the usual manner; produced mesally into a long tongue-shaped process which distally is enlarged and sub-truncate and which extends ventro-cephalad between the legs of the first pair. Claw of legs small, concealed with hair which clothes the distal end of legs sub-densely.

First pair of gonopods in the male with the anterior division much shorter than the posterior, strongly and subquadrately enlarged distad and clothed densely with long hairs. The anterior branch with the more slender distal portion bent first mesad almost at right angles and then caudad parallel with the axis of the body, drawn out distally to a narrow, slightly rounded point, the lower margin of the mesally extending division irregularly toothed. See Pl. XL, figs. 1, 2 and 3.

Second pair of gonopods inserted a considerable space from the base of the anterior pair, above base curving forward parallel to the body and then curving ventrad in engagement with the inner branch of the first pair. From about the end of the first third of the length arises a slender process which in lateral view appears to terminate in a spear-shaped head, this process crossing the main branch in a caudo-dorsal direction. Main process terminating in two branches, a broad plate-like branch through which the duct opens and a more slender acute process springing from the ventral aspect of the former. See further Pl. XXXIX, figs. 6 and 7.

Width of body 2.6 mm. Length uncertain, the caudal end of the body missing.

Locality—Sacramento Mountains, New Mexico. (T. D. A. Cockerell.)

Paraiulus tiganus sp. nov.

Deep brown to almost black. A yellow to white stripe encircling the body at junction of adjacent segments and a narrower line-like ring of same color encircling each segment near transverse suture. On the dorsum of each segment each side of the median and on the anterior portion of segment is a curved light line, the concavity of which is caudad. A dorsal median longitudinal line of black which is thickest on each segment between the mesal ends of the two curved light lines. A row of black dots along each side, there being a dot on each segment cephalad of the narrow light ring. Back of each black dot is a white one which encloses spiracle. First dorsal plate deep brown or blackish, a solid black band along the cephalic border which is extended caudad mesally, narrowly edged with pale. Vertex of head dark brown; clypeus and an area on each side embracing insertion of antenna and extending ventrad from it pale; eye patches and a triangular area between them and extending ventrad black, the median area including three light dots. Antennae blackish. Legs brown to yellow. Last plate like the first one, deep brown or blackish, narrowly edged with pale.

Head with a furrow-like depression between the two eyes, the fine median longitudinal line extending from this across the vertex.

Eye areas oval but with the inner ends obliquely truncate. Ocelli convex, arranged in eight transverse rows as follows, counting from above ventrad: 4, 8, 9, 9, 10, 11, 9, 5, making a total of 65, in the specimen described.

Antennae of medium length, slender.

Cervical plate large. A weak median longitudinal impression which is obsolete on anterior portion. Lower lateral portion impressed with a longer striation near and subparallel with margin and dorsad of this and extending from the caudal margin a second, short stria, one or two other similar ones sometimes indicated.

Other segments sharply striate beneath. Spiracles small, not touching the transverse suture which is sinuate at its level.

Anal scutum smooth. Distal portion triangular, the apex sharply angular, straight, not at all decurved.

Anal valves with the mesal margin elevated, setigerous.

Anal scale roughly triangular; each lateral side mesally convex; incurved adjacent to proximal and distal angles; cephalic margin widely convex.

Male: Gnathochilarium with stipes not produced mesally. The very large promentum obovate, a little crenately incised each side of the middle on distal margin and also proximad of each disto-lateral corner. Hypostoma free except laterally. See Pl. XL, fig. 6.

First legs of male strongly enlarged, uncinate. The inner surface tuberculate as usual, and bearing long bristles as shown in the figure.

Second legs of male reduced excepting for greatly enlarged coxae, as usual; the claws small. See Pl. XL, fig. 7.

Gonopods of male large and conspicuously exposed. The anterior pair with the mesal branches a little the longer, attenuated from the base distad but produced caudo-laterally near or a little below its middle height. Outer branch clavately enlarged distad, embracing the first on the antero-lateral surface; pilose with long hairs over the distal end and proximally along the disto-mesal face for part of the length.

Posterior gonopods with the outer distal branch somewhat clavate apically and densely pubescent with fine short hairs. Inner branch almost straight, blade-like, acutely pointed. From the inner edge of the outer branch springs a third, spine-like, process which extends distad between the two main ones. See Pl. XL, fig. 8, and Pl. XLI, figs. 1, 2, and 3.

Length of a male 55 mm. Width 3 mm. Length of antenna ad 3 mm. Number of segments 51–57.

Locality—Canyons of the Wahsatch Mountains, Utah.

The most common diplopod in Utah. It is evidently closely allied to P. furcifer, which it resembles much in general appearance and in the general type of gonopods in the male. The latter are readily to be distinguished, however, both from characters in the anterior pair and especially those of the pos-

terior pair which differ in ending in three processes instead of in two, a slender spinous process appearing between the two major ones which are alone present in P. furcifer, etc.

Paraiulus furcifer Harger **var. sinampus**, new.

A row of small dark, inconspicuous dots along each side toward dorsum, the dorsum above and between the two rows of dots light yellowish brown, the sides below the dots distinctly darker, brown; each segment with a dark blackish brown to black annulus which is broadest across dorsum and narrows ventrad down each side; a narrower and rather less deeply colored dark line along junctions of adjacent segments which below disappears in the brown of the sides. A fine median dorsal dark line, on each side of which on each segment is a yellowish white line which does not extend laterad as far as the line of dark dots. First dorsal plate dark brown or chestnut, especially the caudal border pale. Penult and antepenult segments and the proximal portion of anal scutum pale. Venter pale. Legs medium brown. Vertex of head black, the dark area extending ventrad between the antennae; clypeal and lateral regions of head pale. Antennae black or blackish.

Body in the not fully adult male being described somewhat constricted caudad of head, the first segment narrower than the second and subsequent ones.

First segment moderate; the lateral margins running obliquely from caudal edge of head ventro-caudad to junction with posterior margin which curves forward to angle. Lower lateral portion of plates marked with two distinct striae which extend forward a short distance from the caudal margin, in addition to the line margining the lateral edge. Caudal border not margined, the anterior one obscurely so.

Second segment with the lower lateral border extended ventrad mesally in an acute angle of which the cephalic side is much the longer. Deeply striate beneath, above somewhat roughened, as on subsequent segments.

Spiracles more or less elongate longitudinally, moderate, separated from the transverse suture which is somewhat weakly quadrately emarginate opposite them.

Anal plate not roughened. Distal portion subtriangular, straight, apically somewhat rounded. Extending a little beyond the anal valves.

Anal valves with mesal edges narrowly margined, not elevate. Each valve with a longitudinal impression ectad of its middle.

Anal scale subtriangular, the caudal angle acute, not at all rounded.

Legs rather long. Dorsally glabrous. Inner surface with longitudinal series of stout, spinescent setae.

Head roughened with areolations formed by a network of impressed lines. A bow-shaped line impressed between inner angles of the two eye areas, the line angularly bent dorsad at middle where it is joined by the median longitudinal line of the vertex. A wide, shallow, median depression from frontal region to clypeus which is deepest ventrad. Head furrowed below eye area on each side from base of antenna toward gena and then dorsad along the border of the head.

Eye area large, subtriangular, the dorso-mesal and ventro-lateral sides convex and the ventro-mesal nearly straight. Ocelli arranged in eight straight transverse rows which, counting from above ventrad, are as follows: 8, 10, 9, 8, 7, 6, 5, 3, making a total of 56.

Antennae slender, a little enlarged distally, the sixth article thickest. Clothed with short hairs intermixed with longer ones, the hair more dense distally.

First legs of male thickened, but as yet straight and not distally hamate. Coxae fused in middle line. See Pl. XLI, fig. 8, and Pl. XLII, fig. 2.

Second legs not as yet reduced, as large as the third but the four distal articles forming a hook which seems firm and is directed cephalad. Claw large.

Lower margin of seventh segment but slightly angularly extended. Gonopods enclosed in a single sheath, the body being very long and presenting indications of the separate pieces only distally. See Pl. XLI, figs. 5 and 6. Upon removal of the envelope the copulatory organs are revealed in their usual character and relations, but the posterior pair not yet engaged distally with the inner branches of the anterior pair as in the adult furcifer, its two prongs being straight and closely appressed together and the outer one distally pilose. Outer branch of anterior pair provided with long hairs as in the adult furcifer.

Number of segments 58.

Locality—Portland, Oregon (1902).

The description above is of a male which as indicated previously, is not wholly mature, although apparently or probably within one moult of being so. While the copulatory organs when released from the peculiar sheath are seen to be fully formed and in most respects in close agreement with those of typical furcifer, the coloration is markedly different from that usually found in P. furcifer of the corresponding age. Furthermore, an adult female collected at the same time has precisely the same coloration and differs from furcifer. It has seemed best to designate the form for the present at least, therefore, as a distinct variety. Because of the interesting points presented the young male is described in full and illustrations of a number of its features presented.

FAMILY PAEROMOPIDAE.

Paeromopus lysiopetalinus Karsch.

Figures of this interesting form, so long obscure as to its affinities because of incompleteness of the original description and lack of specimens in collections, are presented in Plate XLII, figs. 3 to 5, and in Plate XLIII, figs. 1 to 3. The author has specimens of this form from Portland, Oregon, and from Pacific Grove and Stanford, California.

FAMILY CAMBALIDAE.

Paiteya, gen. nov.

Eyes fairly well developed, consisting of a moderate number of ocelli arranged in two or more rarely in three transverse series.

Antennae short, a little clavately thickened distad. Second article longest, the sixth next; the others much shorter, the third, fourth and fifth not much differing in length. The four sensory cones slender and moderately long.

Gnathochilarium narrowest proximally. Promentum elongate, triangular completely separating the laminae linguales which are strongly narrowed proximad.

Body iulus-like in general form. All segments striate beneath; dorsum of segments from the fourth to the antepenult, not inclusive, each with a series of strongly developed keels of which the most ventrad on each side is thickened and bears on the enlarged caudal portion of edge the spiracle.

Legs definitely armed with spiniscent bristles.

First legs of male reduced; with six articles; normally armed.

Second legs of male likewise reduced but otherwise normal in structure.

Type—*Paiteya errans* sp. nov.

Distribution—Southern California.

Paiteya errans sp. nov.

Brown in transverse encircling bands which, except on anterior segments, alternate with paler yellow bands which are broadest on dorsal surface and increase in extent on posterior segments; fifteen or so of the segments immediately following the fourth with an oval pale spot enclosed in the dark band laterally, these spots on posterior segments becoming confluent on the caudal side with the yellow of the adjacent yellow stripe; first four segments usually unmarked laterally with any such pale spots. A row of black spots on each side in line with the spiracles and extending caudad as far as the antepenult segment, not inclusive; these dark spots sharply defined excepting on the most anterior segments where they tend to be more diffuse and commonly enclose a paler area. First four segments commonly with a pale transverse band on dorsum, this band narrow at mesal line and expanded laterally, commonly areolated with dark. All dorsal carinae dark along their edges. Anal scutum brown excepting the caudal portion. Venter, legs and antennae yellow. Vertex crossed by a transverse yellow band which expands about the black eye area on each side. Between eye and antenna of each side and those of the opposite is a broad brown area which is often areolated with pale. Head below this latter dark band yellow.

Body constricted caudad of head, most strongly so over from about fourth to ninth segments.

Eyes in adults with ocelli in two rows which run a little oblique to the lateral portion of front margin of the first segment, which covers several of the more caudal ocelli. Ocelli commonly about nine arranged with the greater number in the dorsal series, thus: 6, 3; occasionally a single eye in a third row. Eye area extending almost transversely.

Antennae short. A little clavately thickened. The second and sixth articles longest; others distinctly longer than broad. Proximal articles sparsely provided with hairs of moderate length, especially toward the distal ends, the distal articles more densely clothed.

Gnathochilarium conspicuously broader distally than proximally. Lingual lamellae completely separated by the long, triangular promentum. Laminae strongly narrowed proximally, 2.75 times as long as the greatest width. Mentum toward proximal border with a sharply outlined semi-circular impression which has its concavity distad; wider at base than the median length in the ratio 11:9. Stipites nearly 3.5 times as long as the greatest width, the processes being included. In one specimen the processes of stipes were apparently completely fused together as shown in Pl. XLIII, fig. 4.

First segment nearly as long dorsally as the second and third taken together. Extending over the caudal portion of head. Posterior margin straight. Lateral margins widely rounded from caudo-lateral angles cephalo-mesad. The cephalic margin substraight mesally. Within each lateral margin several longitudinal striae extend cephalad from the caudal margin a mostly short distance.

Second segment with deep striae below, the striae on subsequent segments extending farther dorsad, on all but the most anterior and the most posterior reaching the lateral carina which is borne on all but the first segments. Spiracles beginning on the fifth segment. Dorsum of segments from the fourth to the antepenult (not inclusive) each with six strongly developed carinae, of which the lowermost on each side is conspicuously thickened. A weak, fine median keel along dorsum.

Anal scutum large, smooth, caudally rounded.

Anal valves exceeding the anal plate, the free margin thickened.

Legs without true hairs; but armed with definitely arranged spines or spinescent bristles. Claws very large, each armed with a well-developed spine springing from its base on the ventral side.

In the male the first two pairs of legs are reduced, but otherwise unmodified, having six articles and being normally armed.

Gonopods of male concealed excepting for the distal end of slender curved process which projects caudad on each side from beneath a covering plate.

Number of segments 47-49.

Length 19 mm. Width 1.4 mm.

Locality—Southern California.

EXPLANATION OF PLATES.

PLATE XXX.

Lysiopetalum mutans sp. nov.

FIG. 1. Gnathochilarium. X 70.
FIG. 2. Antenna. X 70.
FIG. 3. Eye. X 70.
FIG. 4. "Ovipositor", lateral aspect. X 39.5.
FIG. 5. The same, cephalic aspect. X 39.5.
FIG. 6. First legs, caudal aspect. X 47.
FIG. 7. Second legs, cephalic aspect. X 39.5.
FIG. 8. Third legs, caudal aspect. X 39.5.
FIG. 9. Fourth legs, caudal aspect. X 39.5.
FIG. 10. Fifth legs. X 39.5.

PLATE XXXI.

Lysiopetalum mutans sp. nov. (cont.)

FIG. 1. Ninth leg, caudal aspect. X 39.5.
FIG. 2. Thirteenth leg, caudal aspect. X 39.5.

Conotyla deseretae sp. nov.

FIG. 3. First legs of male.
FIG. 4. Gonopods of male, caudal aspect.
FIG. 5. Gonopods of male, cephalic aspect.
FIG. 6. Gonopods of male, lateral aspect.
FIG. 7. Eighth legs.
FIG. 8. Antenna.

PLATE XXXII.

Conotyla deseretae sp. nov. (cont.)

FIG. 1. Second legs.
FIG. 2. Third legs.
FIG. 3. Fourth legs.
FIG. 4. Fifth legs.
FIG. 5. Sixth legs.
FIG. 6. Seventh legs.
FIG. 7. Gnathochilarium.

Conotyla coloradensis sp. nov.

FIG. 8. Appendages of second segment of the female.
FIG. 9. Eye.

PLATE XXXIII.

Conotyla coloradensis (cont.)

FIG. 1. Gnathochilarium. X 39.5.
FIG. 2. Antenna. X 87.
FIG. 3. Seventh article of antenna, more highly magnified.

Tingupa utahensis gen. et sp. nov.

FIG. 4. Antenna. X 70.
FIG. 5. Eye. X 87.
FIG. 6. Eye of an immature specimen. X 87.
FIG. 7. Female appendages of the second segment.
FIG. 8. First legs of female. X 70.

PLATE XXXIV.

Tingupa utahensis gen. et sp. nov. (cont.)

FIG. 1. Gnathochilarium. X 87.
FIG. 2. Caudal end of body, dorsal view. X 47.

Tingupa monterea gen. et sp. nov.

FIG. 3. Eye. X 87.
FIG. 4. Antenna. X 87.
FIG. 5. Gnathochilarium. X 70.

Caseya irritans sp. nov.

FIG. 6. Eye. X 87.
FIG. 7. Head and first six segments, lateral aspect.
FIG. 8. Caudal end of body, dorsal view. X 18.5.
FIG. 9. Antenna. X 33.

PLATE XXXV.

Caseya irritans sp. nov. (cont.)

FIG. 1. Gnathochilarium. X 70.

Striaria nasinta sp. nov.

FIG. 2. Antenna. X 70.
FIG. 3. First legs. X 47.
FIG. 4. Gnathochilarium, basal sclerites not shown. X 87.
FIG. 5. Labrum. X 70.
FIG. 6. First segment, caudal aspect. X 39.5.

Fontaria tuobita sp. nov.

FIG. 7. Gonopods, cephalic aspect. X 47.
FIG. 8. Gonopods, caudo-ventral aspect. X 47.

PLATE XXXVI.

Scytonotus piger sp. nov.

FIG. 1. First segment in outline from dorsal aspect. X 33.
FIG. 2. Carina of fourth segment from the ultimate. X 70.
FIG. 3. Carina of fifth segment from the ultimate. X 70.
FIG. 4. Gnathochilarium (proximal portion not shown). X 47.
FIG. 5. Antenna (proximal article not represented). X 39.5.

Polydesmus (*Kepolydesmus* subgen. nov.) *anderisus* sp. nov.

FIG. 6. Antenna.
FIG. 7. First leg of male. X 22.
FIG. 8. Second legs of male. X 22.
FIG. 9. Head and first segment in outline, dorsal aspect. X 22.

PLATE XXXVII.

Polydesmus (*Kepolydesmus* subgen. nov.) *anderisus* sp. nov.

FIG. 1. Third legs of male, caudal aspect. X 22.
FIG. 2. Gonopods of male, caudal aspect. X 33.
FIG. 3. Gonopods of male, cephalic aspect. X 33.
FIG. 4. Gonopods of male, lateral aspect. X 33.

Polydesmus (*Kepolydesmus*) *sontus* sp. nov.

FIG. 5. Antenna. X 33.
FIG. 6. First segment in outline, dorsal aspect. X 22.
FIG. 7. First legs, caudal aspect. X 33.

PLATE XXXVIII.

Polydesmus (*Kepolydesmus*) *sontus* sp. nov. (cont.)

FIG. 1. Fifth legs, caudal aspect. X 33.
FIG. 2. Gonopods of male, caudo-ventral aspect. X 47.
FIG. 3. Gonopods of male, lateral aspect. X 47.

Polydesmus amandus sp. nov.

FIG. 4. Antenna. X 33.
FIG. 5. Head and first two segments in outline, dorsal aspect. X 33.
FIG. 6. Gonopods of male, lateral aspect. X 70.

PLATE XXXIX.

Polydesmus amandus sp. nov. (cont.)

FIG. 1. Gonopods of male, cephalo-ventral aspect. X 47.

Polydesmus sastianus sp. nov.

FIG. 2. Head and first two segments in outline, dorsal aspect. X 33.
FIG. 3. Antenna. X 44.

Polydesmus socarnius sp. nov.

FIG. 4. Head and first two segments in outline, dorsal aspect. X 39.5.
FIG. 5. Antenna. X 33.

Paraiulus zakiwanus sp. nov.

FIG. 6. Posterior gonopods of male, lateral aspect. X 33.
FIG. 7. Posterior gonopods of male, cephalo-dorsal aspect. X 33.

PLATE XL.

Paraiulus zakiwanus sp. nov. (cont.)

FIG. 1. Anterior gonopods of male, cephalic aspect. X 33.
FIG. 2. Anterior gonopods of male, caudal aspect. X 33.
FIG. 3. Anterior gonopods of male, lateral aspect. X 33.
FIG. 4. First legs of male, cephalic aspect. X 18.5.
FIG. 5. Second legs of male, caudal aspect. X 33.

Paraiulus tiganus sp. nov.

FIG. 6. First legs of male, cephalic aspect. X 18.5.
FIG. 7. Second legs of male, caudal aspect. X 33.
FIG. 8. Posterior gonopods of male. X 22.

PLATE XLI.

Paraiulus tiganus sp. nov. (cont.)

FIG. 1. Anterior gonopods of male, cephalic aspect. X 18.5.
FIG. 2. Anterior gonopods of male, caudal aspect. X 18.5.
FIG. 3. Anterior gonopods of male, lateral aspect. X 18.5.
FIG. 4. Gnathochilarium of male. X 22.

Paraiulus furcifer sinampus var. nov.

FIG. 5. Distal portion of sheath of gonopods in immature male, cephalic aspect. X 33.
FIG. 6. The same, lateral aspect. X 33.
FIG. 7. Gnathochilarium of same specimen.
FIG. 8. First and second legs of same specimen, lateral aspect. X 33.

PLATE XLII.

Paraiulus furcifer sinampus var. nov. (cont.)

FIG. 1. Labrum. X 70.
FIG. 2. First legs of same specimen, caudo-ventral aspect. X 33.

Paeromopus lysiopetalinus Karsch.

FIG. 3. First legs of male, caudal aspect. X 18.5.
FIG. 4. Posterior gonopods of male, cephalic aspect. X 18.5.
FIG. 5. Anterior gonopods of male, cephalic aspect. X 18.5.

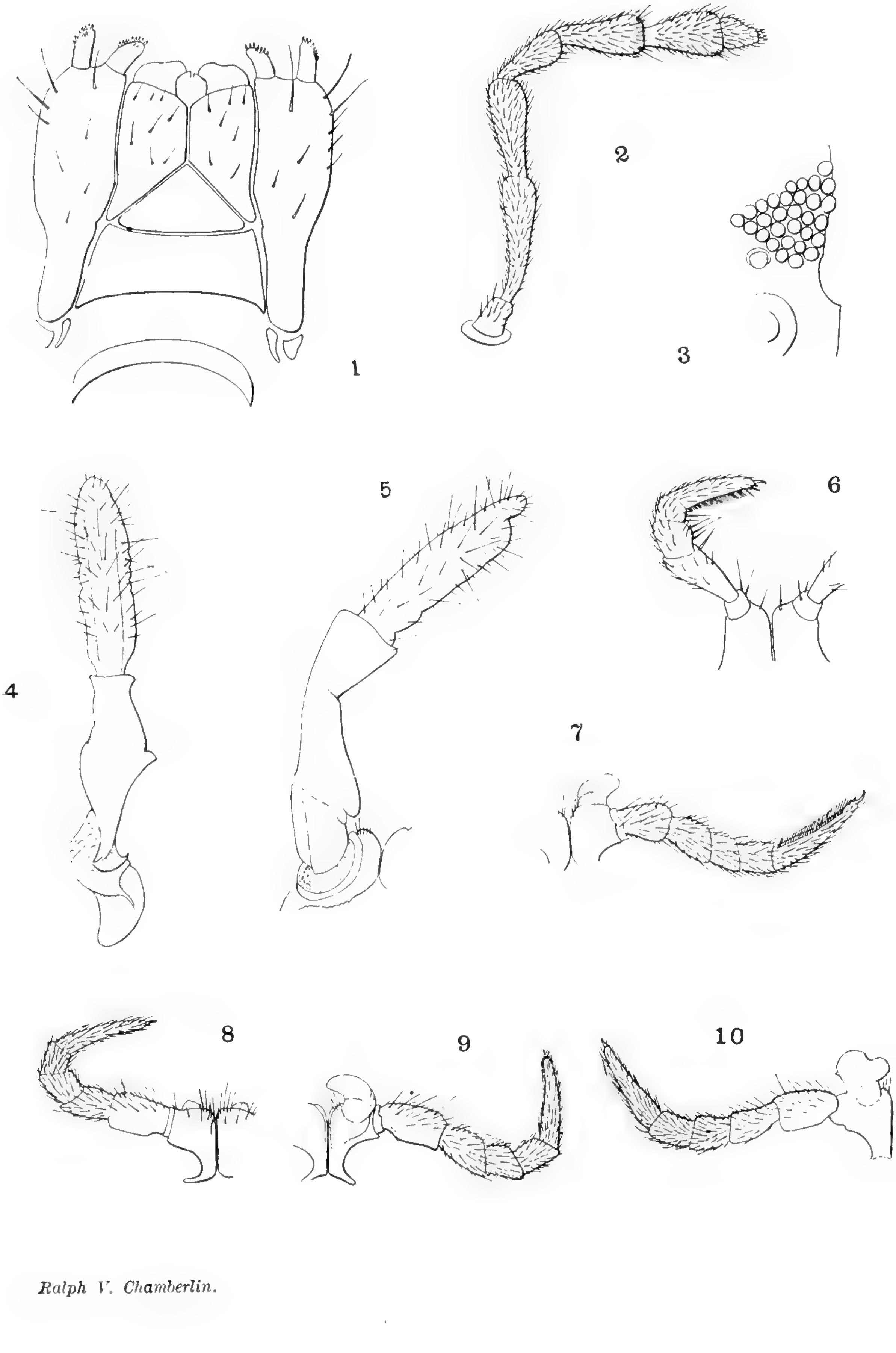
PLATE XLIII.

Paeromopus lysiopetalinus Karsch (cont.)

FIG. 1. Gnathochilarium. X 18.5.
FIG. 2. Antenna. X 18.5.
FIG. 3. Second legs of male, showing penial process. X 18.5.

Paiteya errans gen. et sp. nov.

FIG. 4. Gnathochilarium. X 70.
FIG. 5. Eye. X 87.
FIG. 6. First legs of male, cephalic aspect. X 70.
FIG. 7. Antenna. X 47.



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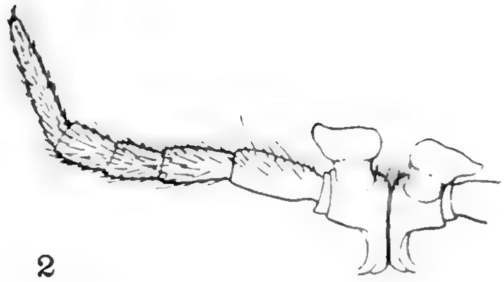

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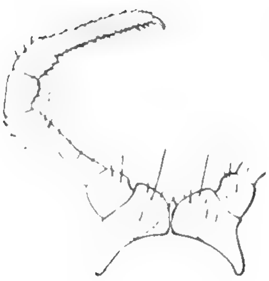

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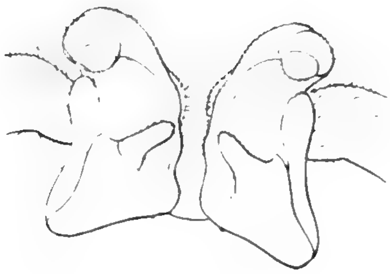

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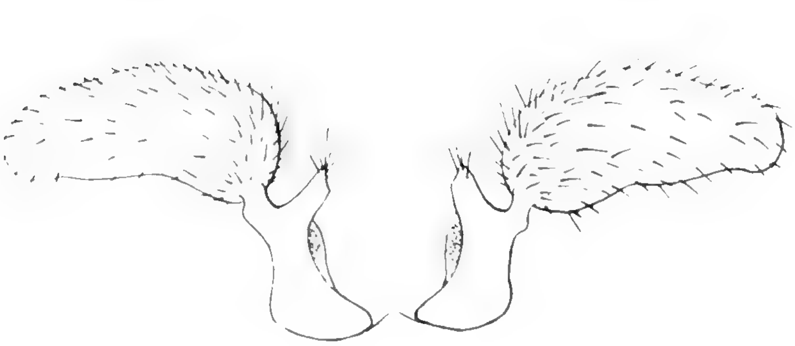

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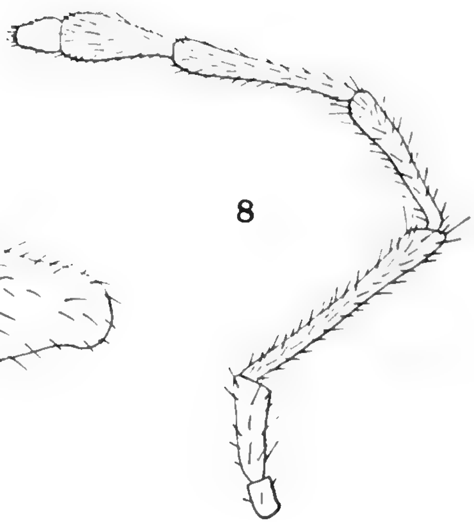

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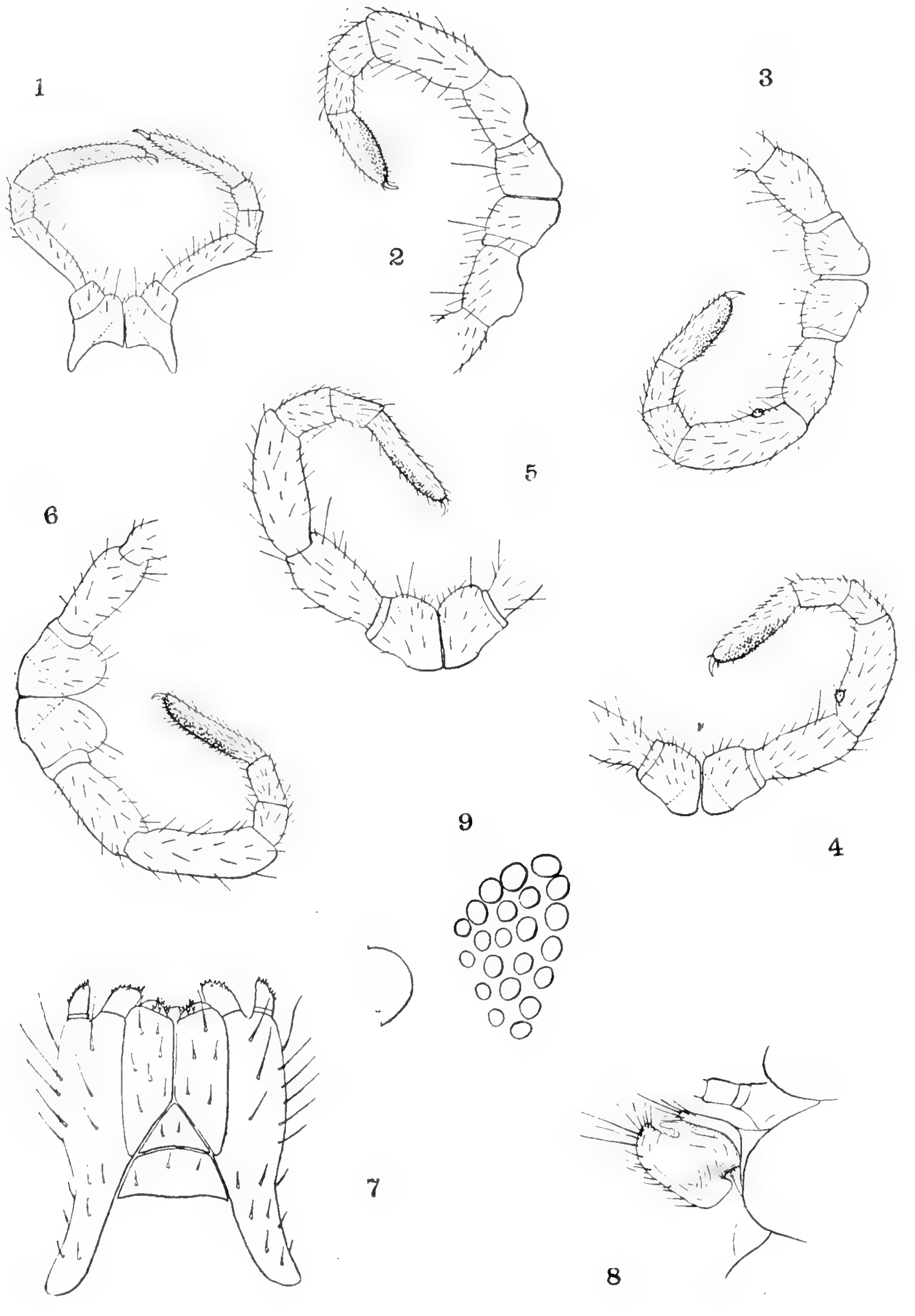

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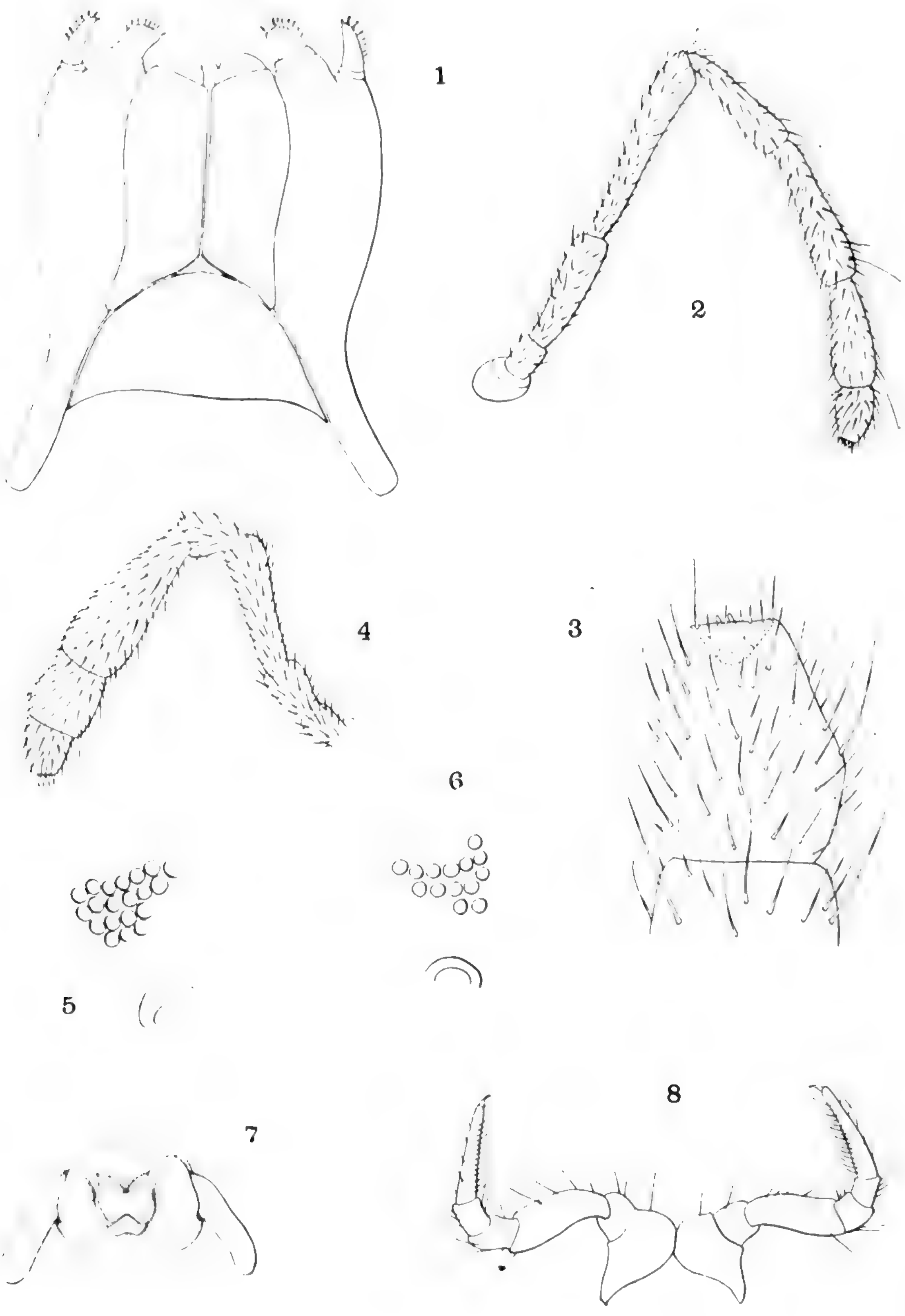

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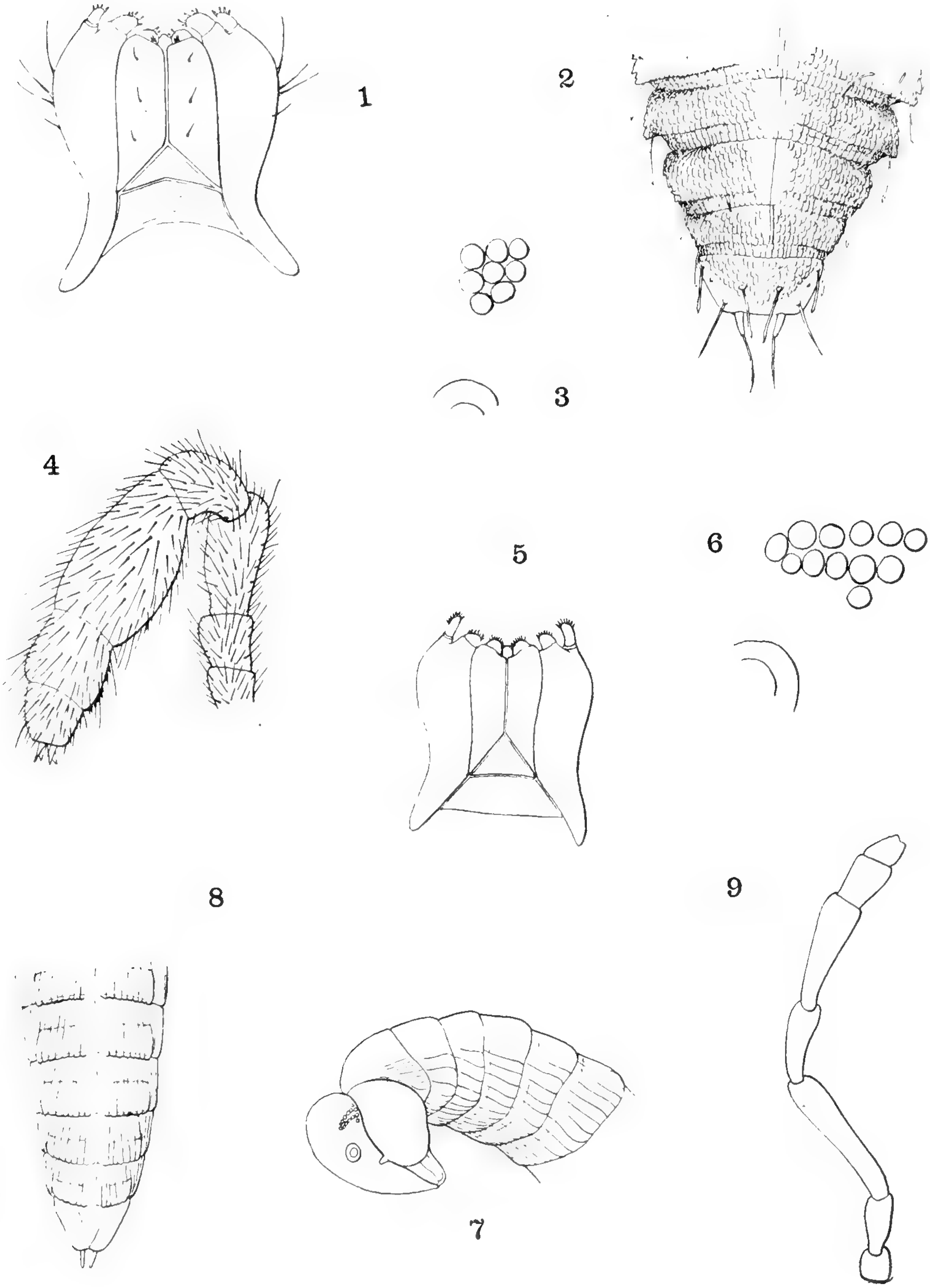

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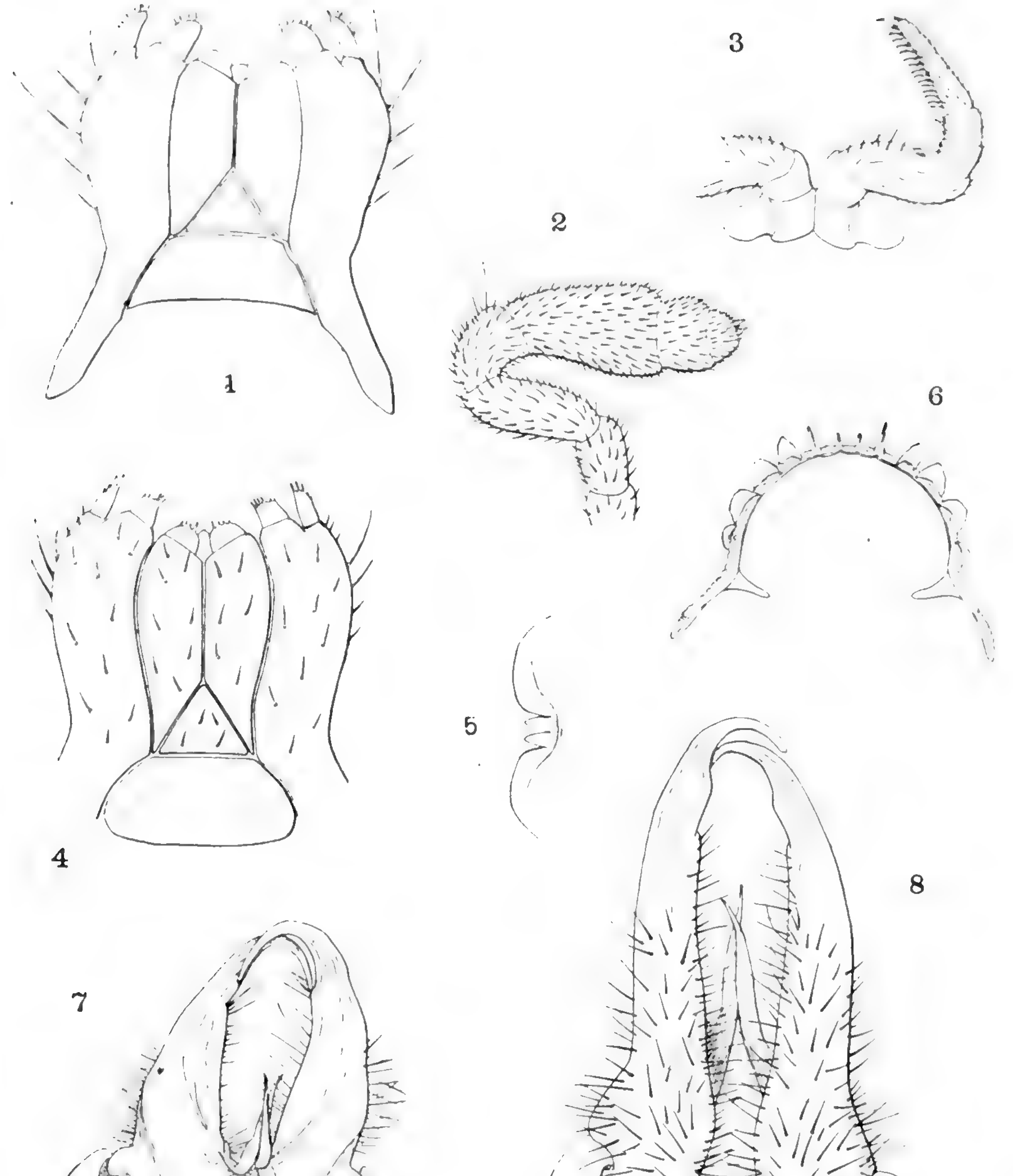

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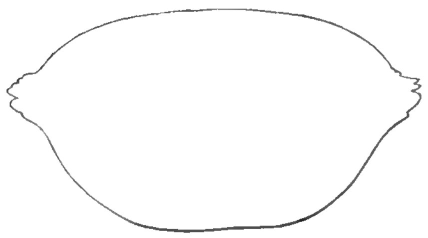

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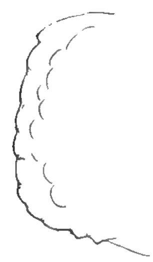

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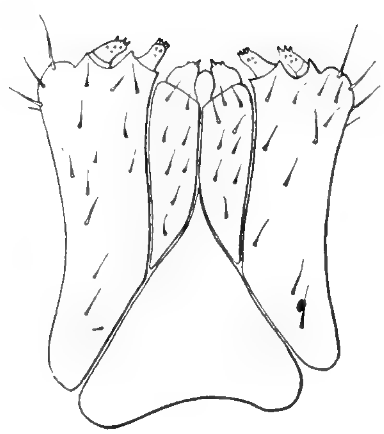

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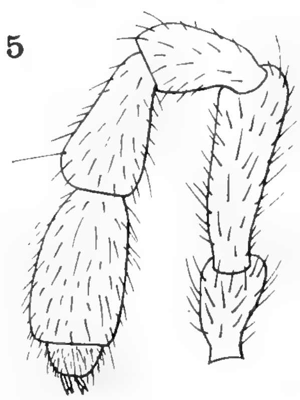

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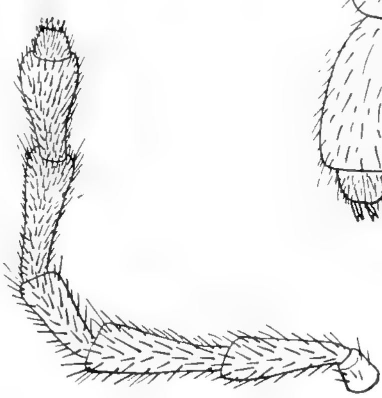

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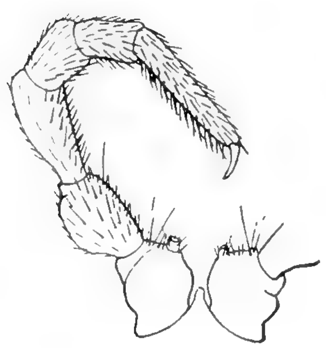

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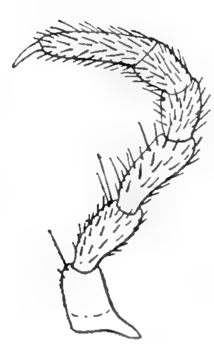

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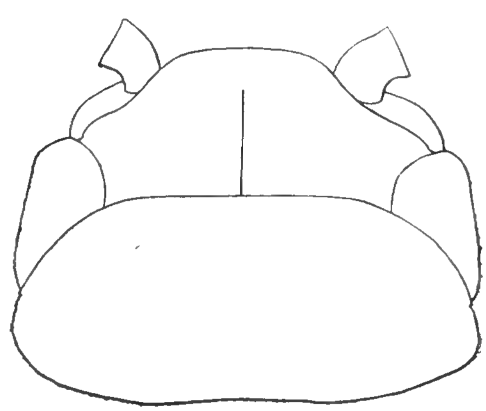

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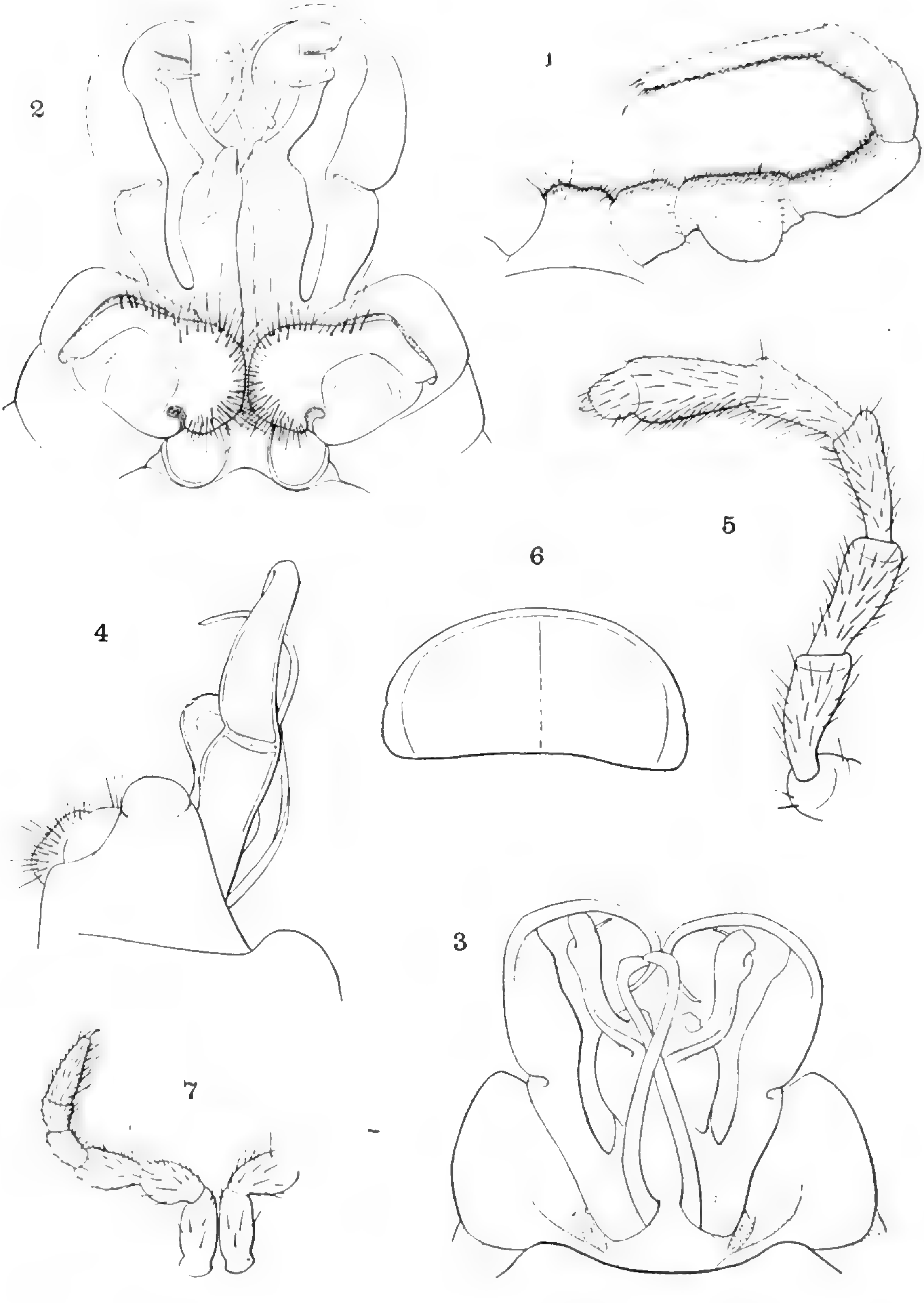

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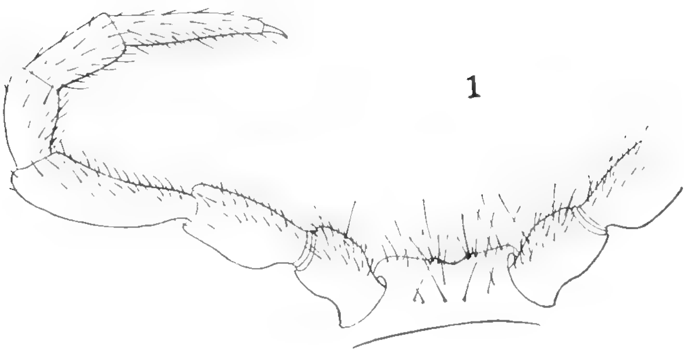

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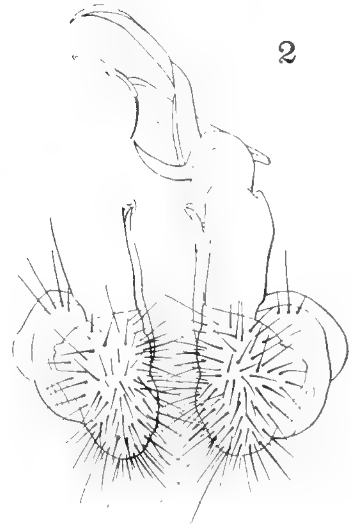

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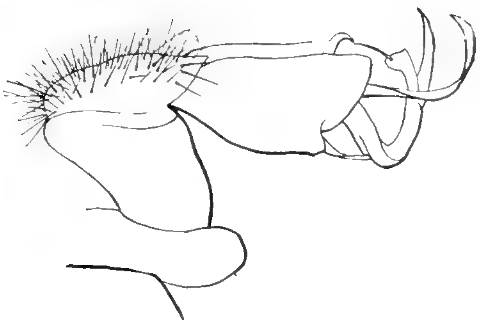

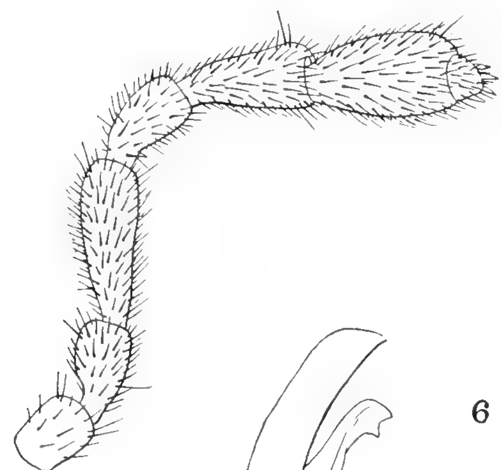

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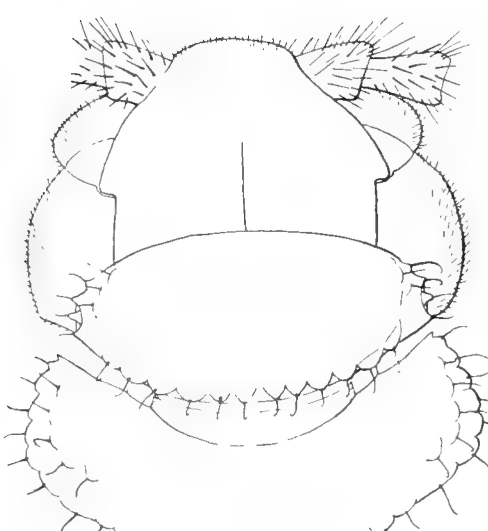

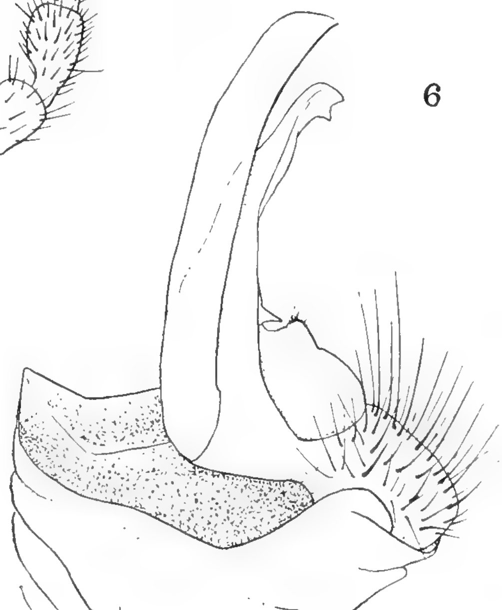

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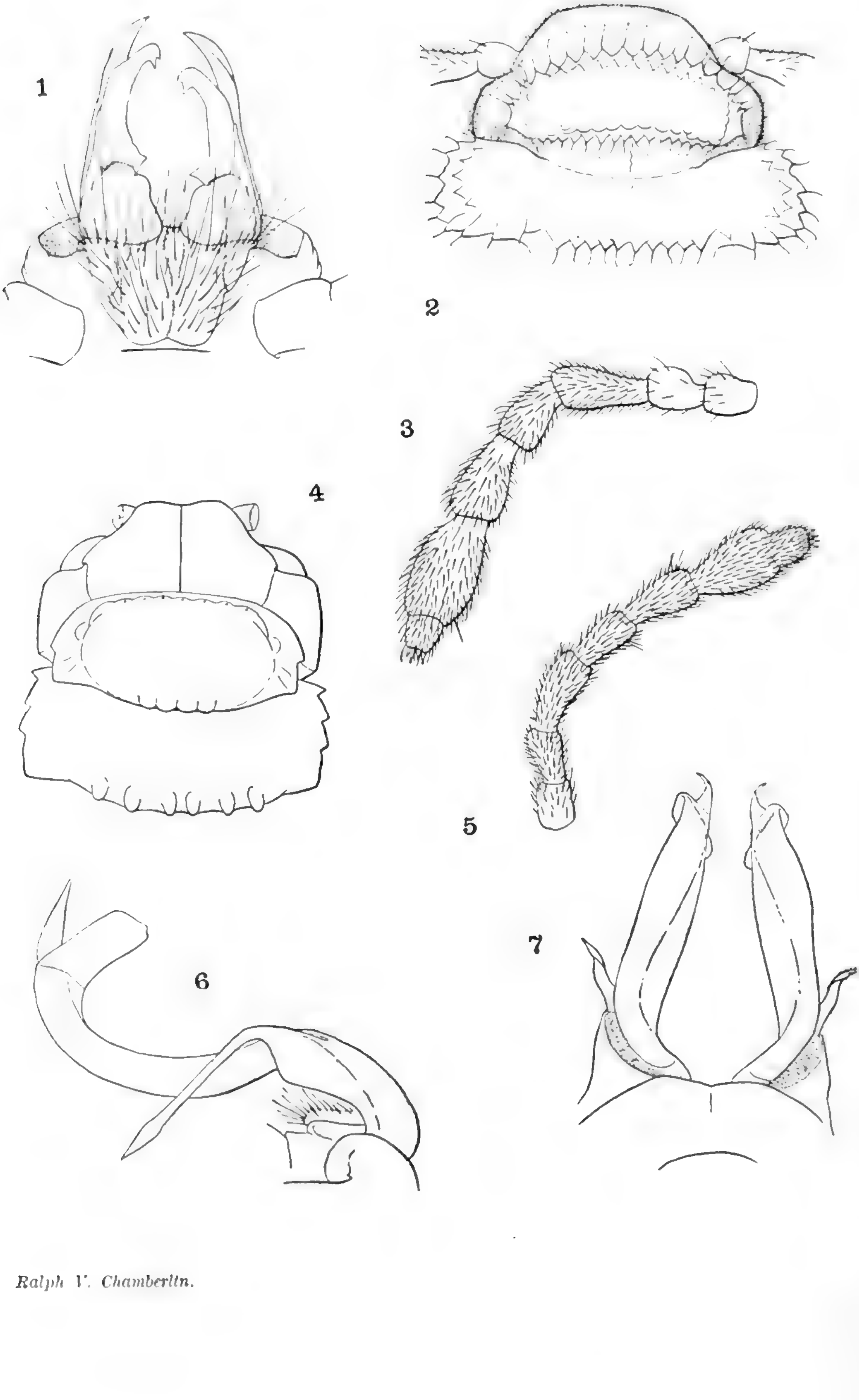

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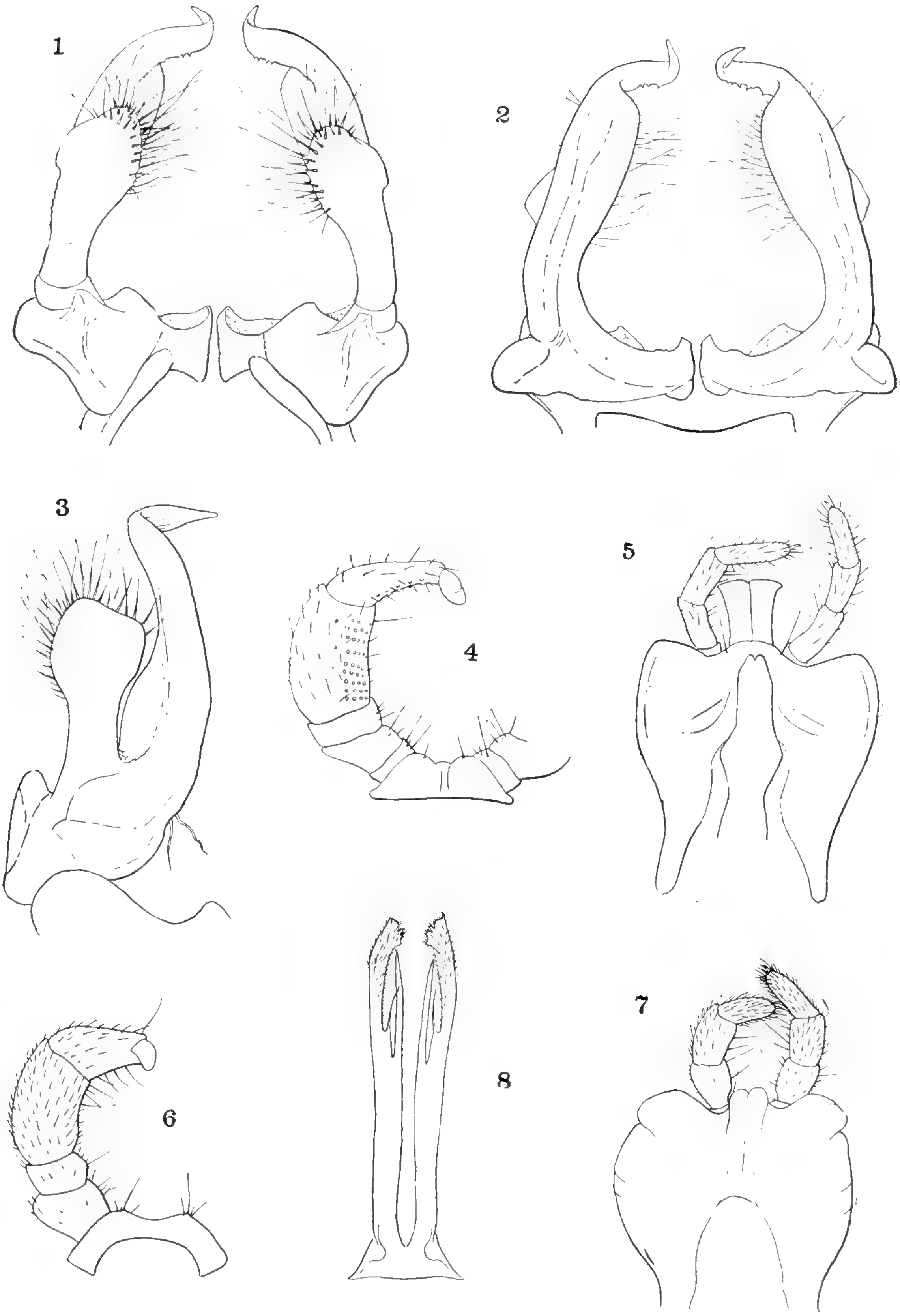

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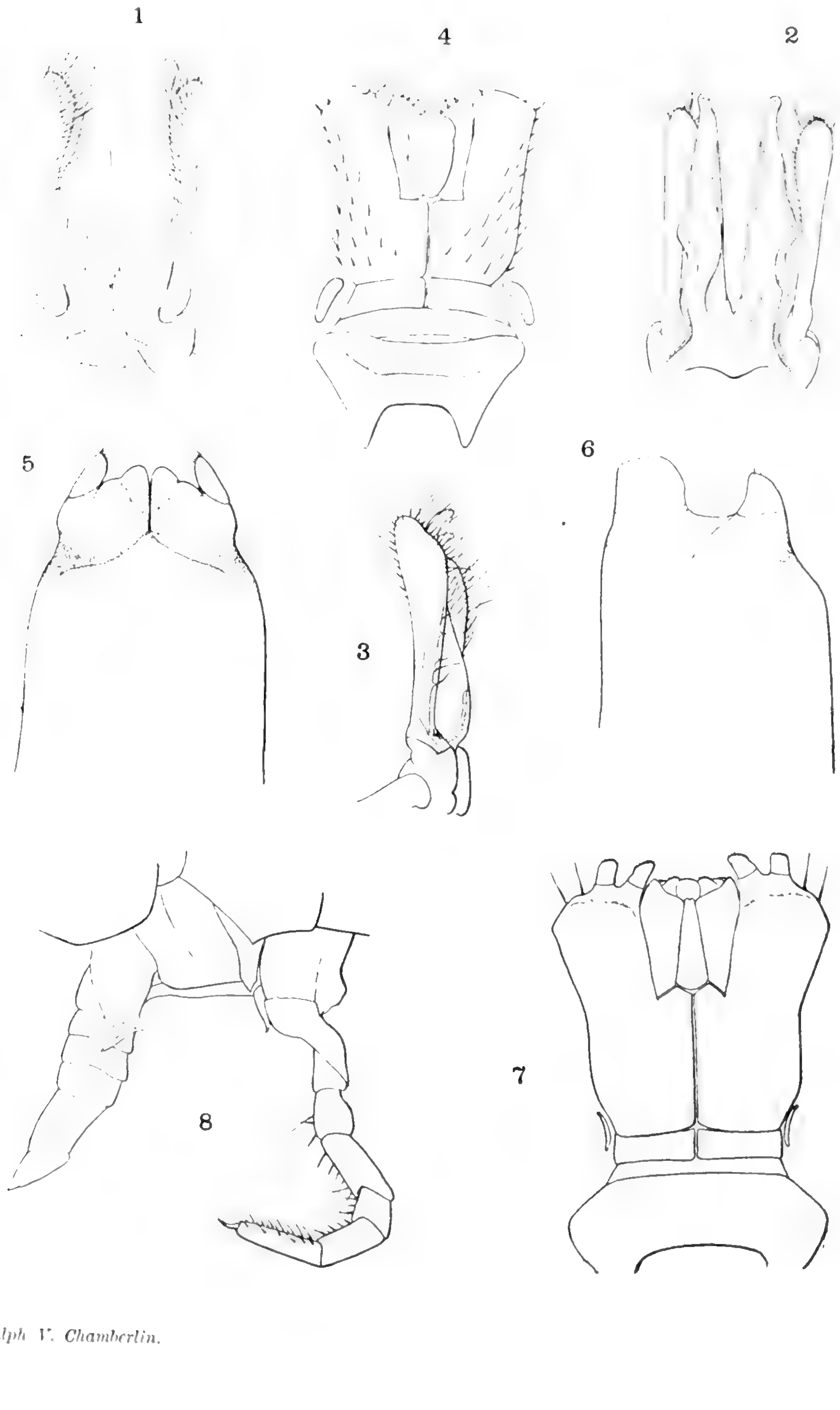

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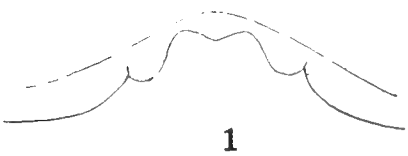

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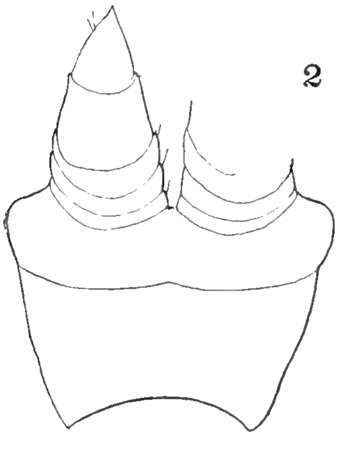

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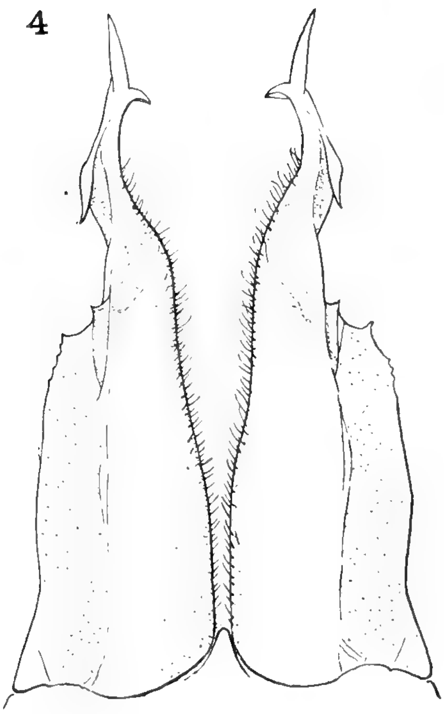

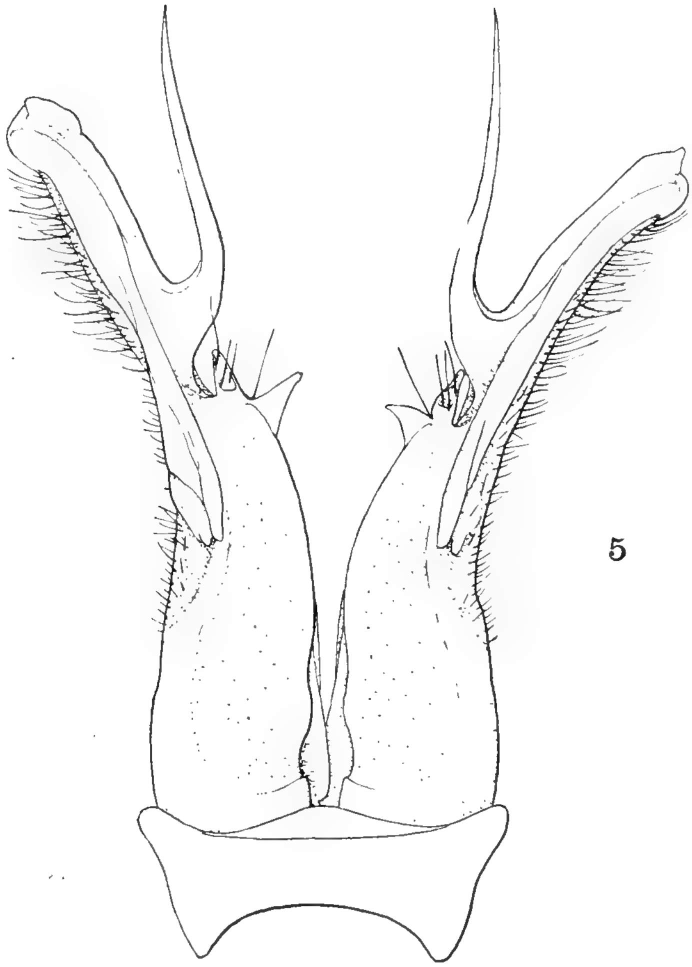

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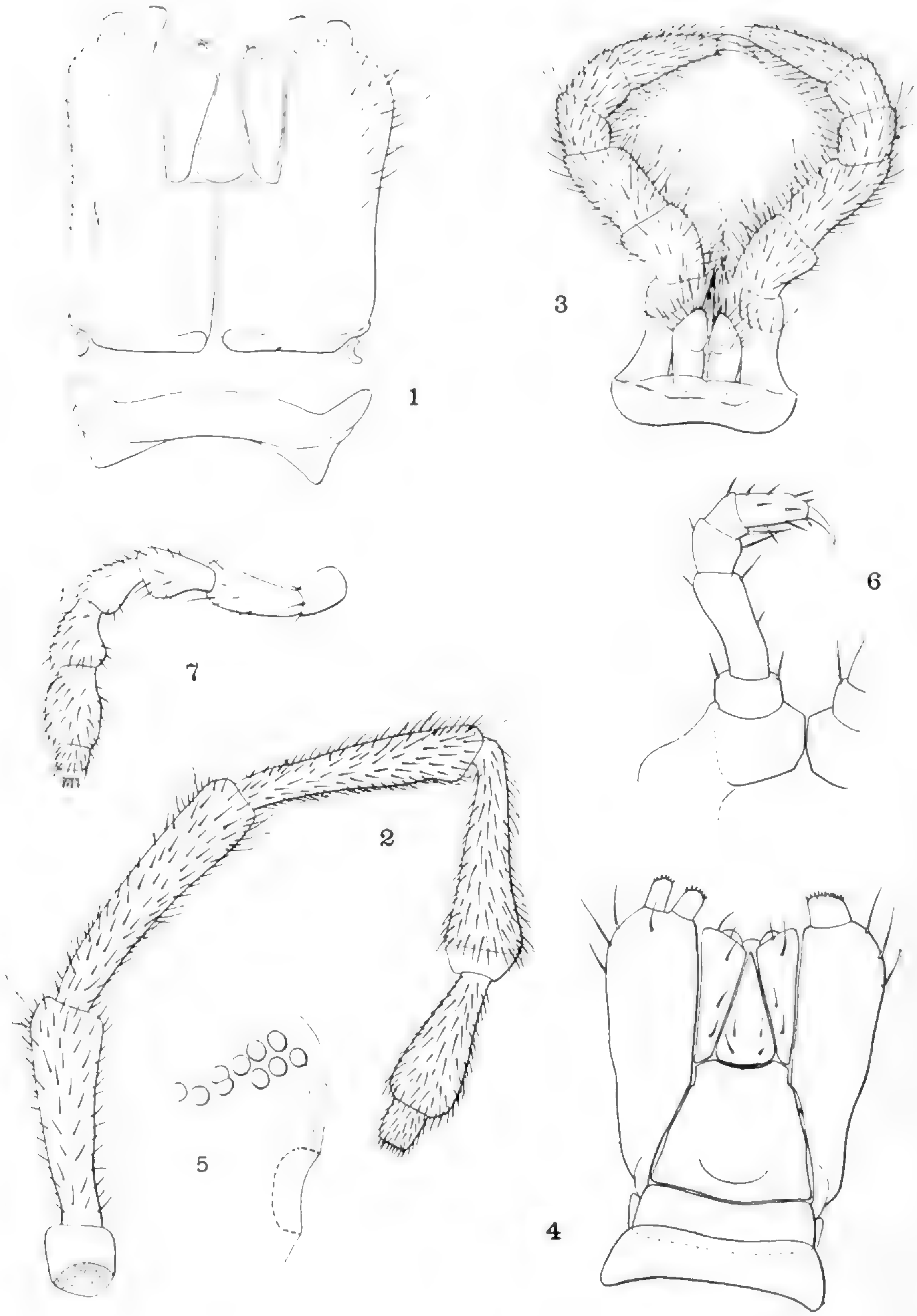

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THE STRUCTURE AND METAMORPHOSIS OF THE ALIMENTARY CANAL OF THE LARVA OF PSYCHODA ALTERNATA SAY.*

By Leonard Haseman.

The changes which take place in the digestive epithelium of insects after feeding, and in connection with the molting periods, have been but little studied, though in the cases known the phenomena are of great interest. In some insects partial, in others, total regeneration of the mid-intestinal epithelium has been found to occur after each taking of food. In other instances it is the changes associated with molting which have attracted attention. It was with a view of studying the morphological changes in the epithelium at the two periods and of correlating the results with those of previous workers that this study of the larva of Psychoda alternata was undertaken.

A review of the literature shows that but little has been done along these lines with larval forms. Aside from the work of Van Gehuchten ('90 and '93) on Ptychoptera contaminata, Mobüsz ('97) on Anthrenus and Folsom and Wells ('06) on Collembola, we find only scattered references here and there in more general papers on the digestive system. Psychoda alternata has been selected for the present work because of the ease with which it can be secured and bred throughout the year, its wide distribution, its convenient size for work and the fact that it is one of the most generalized Diptera.

This study was carried out in the Entomological Laboratories of Cornell University, and to Professor J. H. Comstock, I am greatly indebted for valuable suggestions and criticisms. The subject was suggested and the work done under the immediate supervision of Dr. W. A. Riley, to whom I am especially obligated for constant advice and help.

THE STRUCTURE OF THE ALIMENTARY CANAL.

The alimentary canal of the larva of Psychoda alternata is a straight tube extending from the mouth to the anus, without folds, except during bodily contraction when a slight one is formed in the region of the small intestine. Aside from the attachment of strong pharyngeal muscles and the Malpighian

*Contribution from the Entomological Laboratories of Cornell University.

vessels, the surface of the canal for its whole length is unbroken (Fig. 1). From the exterior the division into fore-, mid- and hind-intestine is distinctly marked. The short, much constricted fore-intestine extends back to the third thoracic ganglion. Here, by means of a strong esophageal valve, it connects with the very large mid-intestine, which in turn extends back to the sixth abdominal segment, where the somewhat constricted hind-intestine begins.

The opening of the mouth is on the ventral surface of the anterior part of the head. The clypeus and recurved labrum form a rostrum over and in front of it. The labrum bears, on either side of its anterior recurved margin, a fan of bristling hairs (Fig.3 lr.) The area between these fans is armed with numerous posteriorly directed, strong setae and minute serrate chitinous plates. Posterior to this area is a strong V-shaped plate and laterad of it, along the margin, a pair of mesally directed triangular plates. Behind the V-shaped plate comes a group of small chitinous plates, arranged in a circle, and a series of minute setae. A pair of small plates, bearing numerous minute teeth on their mesal margins, lies laterad of this chitinous ring. Farther back is a pair of lateral tufts of setae and a second pair of oval plates.

The mandibles are strongly chitinized with numerous lateral setae, a single strong spine, with numerous minute teeth on its inner margin, and two long plumes (Fig. 3, md.) On the inner margin are two series of strong teeth, directed at an angle to each other, and a single posterior thumb-like tooth directed cephalad. The hind margin of the mandible is deeply concave to receive the anterior part of the maxilla.

The maxillae are but slightly chitinized, with four short stout teeth on their inner margin, a small median plume and a fan of long setae extending the full length of the lateral margin. The palpi are short and thick with six small papillae and numerous short setae. They are circular in outline and fit into the depressions in the hind margins of the mandibles (Fig. 3, mx.)

The labium is a fleshy lobe bearing numerous fine setae and papillae. On the anterior margin are two small tufts of short setae and behind these a crescent-shaped chitinous plate (Fig. 3, la). The sense papillae found upon the labrum, maxillae, palpi and labium are so placed as to come in contact with the food as it enters the mouth and therefore are very probably organs

of taste. The setae and plumes surrounding the mouth are curved, near their tips, and so arranged as to sweep food into it when the mouth parts are in motion.

The mouth opens almost immediately into the pharynx, which is somewhat expanded dorsally and supported on its cephalo-lateral margins by curving chitinous bars (Fig. 4, ph.) Strong muscles extend from its cephalic, lateral and dorsal surfaces to their points of attachment on the chitinous surface of the head. Posteriorly the pharynx tapers rapidly into the narrow esophagus so that their point of union is hardly discernable. The esophagus is slender, uniform in diameter and extends from the subesophageal ganglion to a point opposite the third thoracic ganglion. The surface of the esophagus is free from any visible suspensory attachments and, to the unaided eye, shows rather indistinctly the arrangement of the circular muscles.

Lying alongside the esophagus, above the first thoracic ganglion, are the salivary glands. They are quite prominent, each about the size of one lobe of the brain, and strongly reniform. From the ventral end of each gland, a minute duct extends downward and forward to a point below the subesophageal ganglion, where the two from opposite sides unite to form the main salivary duct. This duct runs forward below the alimentary canal to the mouth, where, as we shall see later, it opens between the hypopharynx and labium (Fig. 4; d.)

Closely enclosing the pharynx are the commissures connecting the brain with the subesophageal ganglion (Fig. 4, com.) These commissures extend forward and slightly downward on either side until the level of the pharynx is reached when each turns rather abruptly backward and downward to the subespohageal ganglion.

Above the second and third thoracic ganglia, the narrow esophagus is telescoped into the mid-intestine forming the espohageal valve. The diameter of the tube in the region of the valve is much greater than that of the esophagus but less than that of the mid-intestine farther back (Fig. 1, es. v.) The mid-intestine normally is a smooth tube tapering slightly anteriorly from its middle and posteriorly from a point near its union with the hind-intestine. When it is gorged with food, however, its diameter may be more uniform throughout. In surface view the cellular structure of the mid-intestine stands out very distinctly even with low power magnification.

The alimentary canal and especially the mid-intestine is closely and firmly enclosed in columns of adipose tissue. Four longitudinal lateral strands extend the full length of the larva with shorter strands here and there. The adipose tissue and Malpighian vessels form a perfect cushion about the canal and in this way support it in the central part of the body cavity. When the alimentary canal is dissected out the adipose tissue adheres to it and severs its connection with the body wall, and the respiratory and nervous systems. In living larvae numerous fine tracheal branches, from the pair of dorsal longitudinal tracheae, are seen to ramify the fat bodies and send finer branches to the alimentary canal. The nervous connections with the adipose tissue and alimentary canal are much finer and more difficult to discern than are the tracheal connections. Delicate cephalad directed fibers from the large dorsal nerve, which extends caudad from the eighth abdominal ganglion, are seen to attach to the ileum just behind the Malpighian vessels corresponding to suspensory nerves described by Comstock and Kellogg, '95, for Corydalis. These fine nervous connections from below with the tracheal connections from above assist in supporting the alimentary canal.

From surface view the hind intestine is distinctly divided into ileum and colon, while the rectum is less easily made out (Fig. 1). The ileum extends from the point of attachment of the Malpighian vessels, opposite the anterior end of the sixth abdominal segment, to the middle of the seventh segment where it joins the much expanded colon. It is so much narrower than the mid-intestine on the one hand and the colon on the other that, in surface view, it stands out in sharp contrast with them. The circular muscles of the ileum are strongly developed and appear as a distinct transverse surface banding. The walls are very thin and elastic.

The diameter of the anterior end of the colon is twice that of the ileum, while posteriorly it tapers to the rectum where it is about equal that of the ileum. The walls of the colon are very thick and but slightly elastic. The circular muscles are strongly developed and are imbedded in pits in the epithelium.

The rectum is quite short, extending from a point opposite the anterior end of the eighth abdominal segment, where the canal bends ventrad, to the anus. It is narrower than the colon and the circular muscles are not imbedded in pits. Exteriorly

it is developed into four distinct papillae which surround the anus (Fig. 1, a. p.)

The Malpighian vessels join the alimentary canal at the union of the mid-intestine and ileum. They are five in number, two on the latero-ventral side, two on the dorso-lateral side, and the fifth on the dorsal surface of the canal (Fig. 1, m. t.) The vessels all have an expanded reservoir-like basal portion, which in living larvae is snow-white, but in alcoholic specimens fades out (Fig. 27, c.) The two latero-ventral vessels extend far forward to a point opposite the middle of the mid-intestine where they make an abrupt turn backward for a short distance. The two dorso-lateral ones start forward but in the middle of their expanded basal reservoirs they turn abruptly upon themselves and their distal ends become closely associated with the reproductive organs opposite the middle of the colon. The dorsal tubule follows the same course, its tip lying free above the middle of the colon. Beyond the expanded basal reservoir, the vessels are much constricted and heavily charged with a reddish-brown pigment in life. The vessels are slightly motile.

Wheeler ('93) claims that the primitive number of Malpighian vessels in insects is six. Where there are less than six, he claims that the reduction is due to a loss or fusion of certain ones, while where there are more than six, he explains it as being due to a division of some of them. However this may be, it is well known that the vessels are usually paired, that is, there is an even number of them. It is rare to find an odd number of Malpighian vessels in insects. Wheeler reports seven for a Neuropterous larva, probably Chauliodes, and the same number is found in the larva of Corydalis cornuta. Five Malpighian vessels have been found in Culex and Psychoda. I find this same number in Pericoma. In Psychoda alternata there seems to be no difference in form or structure between the single dorsal vessel and the other four paired vessels. They all join the alimentary canal singly and are about equi-distant. The same number and arrangement are found in the pupal and adult stages.

Surrounding the anal opening are four prominent fleshy lobes. These are direct prolongations from the rectum and have a respiratory function. Numerous fine tracheae extend downward and forward to these, from a constriction in the large longitudinal tracheae just caudad of the vent. These lobes are

slightly protractil, becoming especially prominent in larvae that have been submerged for a considerable length of time. They are homologous with the anal tracheal gills of other insects. Vaney ('02) gives a figure showing the connection of the tracheae with these lobes in a Psychoda larva where the tracheae are far more prominent than in Psychoda alternata.

The chitinous intima of the mouth cavity is quite thick and continuous with that of the mouth parts and surface chitin of the head (Fig. 5, in.) The epithelium is thin except beneath the minute serrate plates on the anterior surface of the labrum where the cells are very long and slender. In longitudinal sections the hypopharynx and epipharynx are very prominent. The epipharynx is closely associated with the back part of the labrum and bears setae and taste papillae (Fig. 5, eph.) The hypopharynx lies immediately above the labium. Its intima is very thick and dark and near its base are strong setae protruding into the mouth of the pharynx (Fig. 5, hy.)

From the back part of the mouth the food passes directly into a large chamber, the anterior part of the pharynx (Fig. 2, ph.) The dorso-cephalic wall of this chamber is very thin and flexible to accommodate varying quantities of food. On either side of this chamber near its anterior end are two strong dorsally directed curving chitinous bars. These bars from opposite sides almost meet above and below and serve as a support for the flexible walls and at the same time bear a series of long yellow ventro-mesally directed chitinous setae which give them a comb-like appearance (Fig. 6, ph. b.) These comb-like structures across the entrance to the alimentary canal function as strainers in keeping out large foreign bodies. The pharyngeal chamber is always more or less filled with food and probably functions as a crop in which the food is mixed with the salivary secretions, by the action of the circular and pharyngeal muscles and these comb-like chitinous structures. The epithelium in this part of the pharynx is quite thin, while the chitinous intima is thick. The circular muscles in this region are by no means so strongly developed as in the caudal part of the pharynx.

The posterior portion of the pharynx is constricted so that its diameter is about equal that of the esophagus. In transverse section it appears pear-shaped, the broader portion being ventrad (Fig. 9.) It is provided with very powerful circular muscles which lie so closely together as to form almost a continuous

layer. The epithelium consists of very large cells, with large oval nuclei, whose nucleoli and chromatin material stain intensely with haematoxylin. The cavity of the pharynx in this region has the shape of a Roman I, a narrow dorso-ventral slit and transverse dorsal and ventral arms (Fig. 9, 1.) The intima of the dorso-ventral slit is very thick and the underlying epithelial cells are very large, cubical and with distinct cell walls. The intima lining the dorsal and ventral arms of the cavity is much thinner and the underlying epithelium is equally reduced in thickness.

The powerful circular muscles serve as constrictors for closing the lumen of the pharynx, while four sets of strong pharyngeal muscles serve as relaxers. On either side of the median portion of the pharynx are two horizontal rows of strong muscles, each row consisting of four separate muscles and a single very large anterior one. These muscles extend laterad and attach at the sides of the head. Their inner ends pass between the circular muscles and are attached to the large cubical epithelial cells by means of numerous radiating, zig-zag strands (Fig. 8, ph. m.) From the dorsal surface of the pharynx at the tips of the comb-like bars is a series of four strong muscles which extend dorsad to the surface of the head, joining it at its caudal margin. Low down on the dorso-cephalic margin of the expanded pouch-like portion of the pharynx are a number of strong muscles which extend dorso-cephalad to the surface of the head. The caudal portion of the pharynx with its heavy chitinous intima and strong constrictor and retractor muscles, must serve as a mill for crushing the food as it is passed on to the esophagus.

The pharynx ends and the esophagus begins beneath the caudal end of the brain (Fig. 4, es.) The circular muscles of the anterior portion of the esophagus completely clothe it, but the individual muscles are less strongly developed than those of the pharynx or those of the posterior part of the esophagus. Longitudinal muscles have not been found in any of the preparations. The epithelium is very thin. The cells forming it are without distinct walls and their small nuclei are arranged in definite rows along the dorsal, lateral and ventral surfaces of the esophagus. The large lateral cells of the pharynx give way in the esophagus to small cells which protrude into the lumen to form a longitudinal ridge on either side (Fig. 10, ep.) The

slight mid-dorsal and ventral protrusions of the epithelium in the pharynx, persist in the anterior part of the esophagus, forming a slight dorsal and a ventral longitudinal ridge. In the median portion of the esophagus these ridges almost disappear while in the caudal region there are two dorsal and two ventral ridges (Fig. 11, ep.) These dorsal and ventral ridges are simply thickenings of the cells opposite the nuclei while the lateral ones are formed by an elevation of the cells from the muscular coat and a protrusion of them half way in to the center of the lumen. The chitinous intima of the esophagus is well developed although much less strongly than in the pharynx. It becomes much folded and is usually severed from the epithelium by fixation. On the inner surface of the infolded intima of the esophageal valve, there are to be seen, with high magnification, a number of strong spine-like setae, but these are absent in the anterior portion of the esophagus (Fig. 17). They are so directed as to resist the passage of food from the mid-intestine back into the esophagus.

The salivary glands are quite prominent, each about the size of one of the lobes of the brain (Fig. 12). They are strongly reniform so that their free ends lie almost directly above their proximal ends. When the glands are not secreting their lumina may be very large, but during active secretion they are nearly obliterated. The cells are very large and protrude into the lumen so that in sections there are deep grooves between them. They have a coarse granular and vacuolate appearance, and are usually set off by distinct walls, except during active secretion when these may become obliterated. The nucleus is very large and centrally located, with deeply staining chromatin material and a very large nucleolus. The chitinous intima is quite thick but obscured by the granular nature of the underlying cells and the secretions in the lumen. The limiting basement membrane is very delicate, but stands out distinctly.

From the ventral anterior end of the glands, ducts pass forward and downward to a point beneath the sub-esophageal ganglia where the two join to form the main salivary duct. This main duct passes forward to the mouth where it opens on the surface of the labium between it and the hypopharynx. The intima of this duct is quite delicate posteriorly while the epithelium is more prominent, but near its anterior end both the intima and epithelium are prominent. Just before the duct

reaches the labium it is provided with a distinct press. The lower surface of the duct is attached to a strong chitinous process from the intima of the labium while a pair of very strong muscles is attached to the dorsal surface (Fig. 6, pr.) These two muscles extend laterad and slightly dorsad to their point of attachment to a prong of the tentorium. By their contraction the dorsal wall of the duct is drawn away from the ventral and the salivary secretions are permitted to escape into the mouth.

The circular muscles of the esophagus become greatly enlarged for a short distance in front of the esophageal valve and for some distance back into it (Figs. 14, 15 and 16, sp.) They thus function as a sphincter. The valve is strongly developed, the length of the inflexed portion of the esophagus being about equal to the diameter of the valve. The epithelium and intima of the inflexed portion are unmodified while those of the reflexed portion are much thinner and in longitudinal section appear as two heavy lines with here and there a nucleus in the epithelium (Figs. 14 and 15.) The reflexed portion extends a short distance cephalad to the anterior end of the mid-intestine and so forms a second, a caudally directed, loop. Circular muscles are absent from the caudal portion of the inflexed esophagus and from all of the reflexed portion. Between the inflexed and reflexed portions there is a large blood space, filled with the granular blood plasma and scattered blood corpuscles and traversed by numerous delicate fiber-like outgrowths of the reflexed epithelial cells (Fig. 16, s.) A number of these fibers and anteriorly protruding longitudinal muscles from the mid-intestine, meet the esophagus opposite the anterior end of the sphincter.

The point of union of the fore- and mid- intestine is plainly set off by the striking contrast between the epithelium of the two regions. The thin epithelium, of the reflexed part of the esophagus, gives way to a girdle of large deeply-staining cells, which extend about half the length of the esophageal valve. In longitudinal section from six to twelve large cells are seen to comprise this group on either side (Fig. 15, gl.) The anterior ones are short, polygonal and lie transversely, but farther back they become strongly club-shaped and are directed mesocaudad. The outer ends of the cells are closely appressed while their inner ends are expanded greatly and form a smooth secre-

tory surface. The nuclei are large, with large nucleoli and coarse, deeply-staining chromatin granules, and lie in the expanded inner portion of the cells. These cells are glandular in nature. They stain far more intensely with haematoxylin than any other cells of the alimentary canal. They are granular and finely vacuolate toward their inner margins, where a thin layer of granular substance is to be seen (Fig. 18, p. m.) The inner margin of this granular layer hardens to form a delicate elastic peritrophic membrane which is continually fed back into the mid- and hind-intestine to envelope the food material. This membrane may be seen as a delicate envelope surrounding the excrement as it is thrown off. In some preparations the formation of the peritrophic membrane from the granular secretion can be seen very distinctly with the 1-12 immersion objective.

There are several views as to the origin of the peritrophic membrane in insects. By Pagenstecher ('64), it was thought to be a product of the salivary glands. Frenzel ('85) thought it was a product of the mid-intestinal epithelium. Simpson ('00) in an unpublished paper described it as a product of the mucus cells in Clisiocampa. Schneider ('87) considered it a chitinous prolongation from the esophagus. Van Gehuchten ('90) and Cuenot ('95) claimed that a ring of cells just cephalad of the mid-intestine produces it. In the larva of Psychoda alternata there can be no doubt as to the origin of this membrane. The girdle of cells at the anterior margin of the mid-intestine secretes it.

Behind and laterad to this girdle of cells comes a second girdle of glandular cells. In longitudinal sections seldom more than two cells are to be seen (Figs. 13, 15 and 46, c. gl.) They are very large, among the largest found in the alimentary canal, coarsely vacuolate, and have a straw-yellow color when stained with iron-haematoxylin. The nuclei are large, with rather small nucleoli and fine deeply staining chromatin granules. The cells pour their straw yellow secretion, which has a uniform finely granular consistency, into a pouch which opens widely into the lumen and extends latero-cephalad between the two rings of cells as seen in longitudinal sections. This pouch-like structure is simply a deep invagination on the inner surface of the gland.

Caecae are usually present in the larvae of Diptera, especially in the more specialized forms. They may be long, as in

the larvae of the blow-fly (Calliphora), but are more often short and inconspicuous. The number of caecae may be two (Ctenophora), four (Tipula, Simulium, etc.) or many as Miall and Hammond ('00) figure for the larva of the Harlequin fly. Vaney ('02) says that in Anthomyia there are four caecae, in Chironomus many, while in Stratiomyia and Tanypus they may be absent. In Tanypus he finds and figures a group of very large vacuolate cells with ectal diverticula which he claims function as caecae. This group of cells is similarly located, and the cells themselves, except for the ectal diverticula, closely agree with those described above for Psychoda. In Psychoda I am convinced that this group of cells is the rudimentary caecal glands. I find it also present in Pericoma. Caecae are said to be entirely absent in the larvae of Lepidoptera, which in this respect would seem to show a relationship between the Psychodidae and the Lepidoptera. There are not wanting a number of other characters which indicate such an affinity.

Behind the caecal gland comes a group of cells very similar to those which secrete the peritrophic membrane (Figs. 14 and 15). The cells stain quite deeply, are elongate and extend meso-caudad. They have numerous vacuoles which usually contain large spherical concretions (Fig. 19, con.) The nuclei are large with distinct nucleoli and intensely staining chromatin granules. The posterior extent of this group is marked by a few greatly elongated cells which project into the lumen (Fig. 14, ep.) It might be supposed that this group of cells assisted the anterior one in the production of the peritrophic membrane but from repeated examination of my specimens no signs of this have been found.

Caudad of this region comes a long stretch of fairly uniform cells. They are very large and cubical or polygonal (Fig. 2, ep.) The ones in front and behind are cubical, while those in the median region are longer than deep. Scattered among the large cells are to be found small slender ones (Fig. 21, ep.) The cells of this region are stained but slightly with iron-haematoxylin, are finely vacuolate, and possess a narrow but distinct striate border. The nucleus is large and the nucleolus and chromatin are sharply differentiated. These cells are secretory but do not take on the greatly elongated condition found in those farther back during most active discharge of secretion.

These large cells grade off posteriorly into a region of tall slender secretory cells (Fig. 2, ep.), comprising the posterior third of the mid-intestinal epithelium. These slender cells are finely vacuolate and have a very strongly developed striate border (Fig. 24, st. b.) The nuclei are small, usually centrally located, with deeply staining nucleoli and chromatin material. During active secretion, groups of these cells increase greatly in heighth and protrude into the lumen, giving to the inner margin of the epithelium a decidedly uneven surface (Fig. 23, ep.) In this respect, this region stands out in sharp contrast with the anterior region of large cells, where their inner margins form almost a straight line. Here and there among these slender cells as well as the larger anterior ones are to be found huge, coarsely vacuolate cells which protrude into the lumen. These have been described as mucus cells (Fig. 46, m. c.)

The striate border is more or less developed throughout the whole length of the secretory part of the mid-intestine, but its greatest development is to be found in the posterior region during active secretion and just before molting. Some of the earlier workers considered the striate border as a chitinous intima perforated by many fine canals. Later work goes to show, however, that it is simply a ciliate border, consisting of non-vibratile cilia, except perhaps in case of Chironomus larvae (Vignon '99). In Psychoda alternata it grades gradually from the vaculate tips of the cells into a clear homogenous border formed by closely appressed fine cilia. So gradual is the gradation and so intimate is the relation between the cell body and the border that I am inclined to agree with Van Gehuchten ('90) that the cilia are continuations of the cells rather than secretions deposited by them upon their inner margin.

The basement membrane is quite distinct throughout the whole length of the mid-intestine (Figs. 22 and 24, b. m.) In places it is considerably thickened. With perfect fixation the basement membrane remains closely connected with the epithelium. It bears on its outer surface, or more often in slight depressions of it, the numerous strands of circular muscles.

In the region of the esophageal valve, and for a short distance caudad, the circular muscles are weak and the strands far apart (Fig. 20, c. m.) But beginning with the region of very large epithelial cells and extending back along it a short distance the bands of circular muscles become much broader and more

regularly placed, with intervening spaces equal to the breadth of the bands. These broad bands give way to narrower and more widely separated ones, which continue back to the region of tall slender epithelial cells. Sections of these strands show their breadth to scarcely exceed the diameter of the nuclei of the underlying epithelial cells. At the point where the large epithelial cells give way to the tall slender ones, the strands of circular muscles are greatly crowded together, having the appearance of a slight sphincter (Fig. 22, c. m.) This crowding of the circular muscles covers but a short area and posteriorly gives way to a greater spacing of them, which extends back to the base of the Malpighian vessels.

The longitudinal muscles are not strongly developed in the mid-intestine. They consist of from ten to twelve narrow, flat strands, which fit closely to the surface of the circular muscles (Fig. 21 and 23, l. m.) Opposite the point, where the circular muscles are crowded together, these longitudinal strands are greatly thickened, almost circular in cross section and stand out from the circular bands more distinctly.

Just at the union of the mid- and hind- intestine are the five Malpighian vessels. In cellular structure they much more closely resemble the epithelium of the mid-intestine than that of the hind-intestine, but their glandular function will account for this, however. From embryological studies it has been shown that these vessels are outgrowths from the hind-intestine. At the point of attachment of these vessels with the alimentary canal they have a short, compact and slightly constricted region (Fig. 26, m. t.) Here the cells are large and alternately from opposite sides extend into the lumen of the vessels giving it a zig-zag course. The nuclei of these cells are oval with small nucleoli and fine chromatin granules. This constricted portion gives way to the much expanded, thin-walled reservoir. The epithelium of this region is very thin, with its inner surface delicately fibrillate and with valve-like projections here and there extending into the lumen (Fig. 27, c.) Beyond the reservoir comes the true glandular portion of the vessel which is much constricted and, in life, is charged with a reddish brown pigment (Fig. 27, a and b). Here the lumen is greatly reduced, being almost closed by the finely granular and vacuolate cells. These cells are very long, as can be seen from longitudinal sections, and as shown by some transverse sections, each cell

almost completely girdles the tubule, and forces the lumen toward one side, but more often the lumen is centrally located, the cell completely encircling the tubule. The basement membrane is strongly developed throughout the whole length of the tubule. The chitinous intima is slightly developed in the distal glandular portion, but seems to be absent in the basal portion.

The change from the mid-intestine to the ileum of the hind-intestine is a most striking one. The large secretory cells of the mid-intestine give way to the very small cells of the ileum (Fig. 26 and 28, ep.) These first cells are so very small that with the 1-12 immersion they appear as mere thickenings of the epithelium. The nuclei are very small, deep-staining, and without prominent nucleoli. A distinct, thin chitinous intima is present. This thin epithelium extends caudad to a point slightly before the middle of the ileum, where it develops a distinct fold, which extends into the lumen to form an ileal valve (Fig. 2, 29 and 31, il. v.) From this point to the union of ileum and colon, the epithelial cells are much larger, with enormous nuclei, in which the small nucleoli and coarse chromatin granules stain deeply. The ileum is well supplied with muscles. The delicate circular muscles of the mid-intestine are replaced in the ileum by very strong bands which completely clothe it. For a short distance, immediately behind the Malpighian vessels, the circular muscles are absent (Figs. 28-29.) From the point where the circular muscles begin, back to the ileal valve, there are two layers of them. The inner layer of delicate bands serves as a sphincter for the ileal valve, while the outer layer is continuous throughout the hind-intestine (Figs. 29 and 30). From the ileal valve back to the colon the individual bands of the circular muscles are much stronger and more oval than those of the anterior part of the ileum. The longitudinal muscles are only slightly developed in the hind-intestine. From longitudinal sections it would appear that, at the point where the first circular muscles appear, the longitudinal muscles divide to form an inner and an outer layer, but from cross sections only outer longitudinal muscles appear in front of the ileal valve. Three strong, and two or three smaller strands appear clustered together along either side of the canal. From the ileal valve to the colon these same lateral clusters of outer longitudinal muscles appear as well as scattered inner strands between the circular muscles and epithelium (Fig. 32, l. m.)

Posteriorly the constricted ileum projects into the expanded colon so as to form a slight valve (Figs. 2 and 33, v.) Just in front of this valve is a strong sphincter composed of five or six strong strands of circular muscles. The colon is slightly shorter than the ileum but its diameter is twice as great. Its epithelium is very thick, consisting of large cubical cells, of uniform finely granular nature, with distinctly striate inner curving margins which project into the lumen (Figs. 35 and 36, ep.) The cell walls are seldom distinct to the base. The nuclei are very large, and oval, with large nucleoli and fine chromatin granules. The basement membrane is very delicate and difficult of detection in most preparations. The circular muscles are strongly developed and are so fitted into pockets in the epithelium that their outer surface is just even with that of the epithelium (Fig. 36, c. m.) Longitudinal muscles have not been observed either in longitudinal or cross sections of the colon as well as the rectum. Sections of close-fitting nerve fibers were at first mistaken for longitudinal muscles. The chitinous intima is but slightly developed and closely adheres to the epithelium. Along the surface of the intima and especually down in the grooves between the cells is a layer of a finely granular deposit which stains blue with haematoxylin. This deposit is present in all of my preparations, which together with the enormous development of the epithelium, would suggest some association with absorption and I am of the opinion that in this larva much of the absorption of digested food takes place here.

The circular muscles of the anterior end of the rectum are much more strongly developed than are those of the colon (Fig. 37, c. m.) They lie on the surface of the epithelium and form a continuous layer. Farther caudad the individual bands decrease in strength rapidly. These circular muscles form a sort of sphincter about the rectum. The nuclei of the circular muscles are very large and are surrounded by undifferentiated protoplasm. The basement membrane is more strongly developed than in the colon. The epithelium is greatly reduced especially in the caudal portion where the cells are long and thin except opposite the nuclei, where they are thickened so as to protrude slightly into the narrow lumen. In the anterior region of the rectum the epithelium is thrown into six longitudinal folds (Fig. 37, ep.) The epithelium of the rectum is continuous

with that of the four slightly eversible anal papillae, where it becomes much thicker and the cells more vacuolate. The chitinous intima of the rectum is much heavier than that of the colon and its thickness increases toward the anus where it is continuous with the chitin of the anal papillae (Fig. 2, a. p.)

MORPHOLOGICAL CHANGES IN THE EPITHELIUM OF THE MID-INTESTINE.

In insects the changes, which the epithelium of the mid-intestine undergoes, are associated either with the pouring out of digestive secretions at the time of feeding or with the larval molting periods. These changes are marked by total or partial epithelial degeneration and regeneration. In the present work, special efforts have been made to get as complete series of larvae as possible in order to show the changes accompanying feeding and molting. By means of carefully timed starvation and feeding experiments, all desired stages associated with the feeding period were easily obtained. But it was much more difficult to get all the stages at the molting period, since the morphological changes in the mid-intestine are largely completed before the skin is cast and there is practically no forewarning as to just when the transformation begins. Only by means of a large series of specimens taken during the inactive period preceding and following the casting of the skin was it possible to get all the desired stages of transformation.

Changes Accompanying Feeding.

The extent of degeneration and regeneration of the epithelium of the mid-intestine, at the time of feeding depends upon the type of secretion found in the epithelial cells. Where the holocrine type of secretion prevails, partial or even total degeneration and renewal of the epithelium will follow each full feeding, while with the merocrine type only slight or no renewal will be found since the epithelial cells are not destroyed by the discharge of secretions.

The nymphs of dragonflies and adult water beetles, in which may be found the holocrine type of secretion, are excellent examples for the study of epithelial regeneration following feeding. Needham ('97) found that, in case of dragonfly nymphs, after prolonged fasts of two months, the cells became so gorged with digestive secretions that the epithelium became twice the height of the normal and when food was taken in

practically all of the cells were destroyed by the process of excretion and a complete new epithelium formed from scattered nidi or regenerating centers. Frenzel ('85), Vangel ('86), Bizzozzero ('93) and Rengel ('97) described even more striking cases of epithelial degeneration and regeneration in adult water beetles of the genera Hydrophilus, Hydrobius, Hydrous and Cybister. These beetles like the nymphs of dragonflies, feed intermittently, being able to fast for periods when food is not at hand and then when food is abundant, devouring great quantities of it. In these bettles the entire epithelium with its basal chitinous membrane is described as being cast off after each full feeding. The new epithelium is quickly developed from highly specialized regenerating centers or nidi, which protrude through the muscular coat of the canal, to form distinct diverticula.

The merocrine type of secretion is found in the mid-intestinal epithelium of those insects which feed continuously and which require a continuous supply of digestive fluids. In these forms the cells are always active, the extent of the secreting activity depending upon the extent of feeding. But since the cells are not destroyed by secretion and excretion there is no occasion for any regeneration in connection with the intake of food and digestion. This type of epithelial secretion was described by Van Gehuchten ('90 and '93) for Ptychoptera contaminata, there being no epithelial regeneration associated with digestion. Folsom and Wells ('06) describe this as the prevailing type of secretion in the mid-intestine of Collembola, there being no regeneration at the time of feeding.

Psychoda alternata in its larval state is not an intermittent feeder but is most at home at the mouth of open sewers, in cultures of decaying horse manure or other vegetable ferments, where it finds abundance of food always present. An occasional plankton form may be found mingled with the food but the bulk of the intestinal contents consists of bits of decayed vegetation. The larva is a voracious feeder and extremely active, scarcely refraining from feeding long enough to molt. The canal always has a great quantity of food material in it, even at the molting periods. From careful study of the epithelium of the mid-intestine of this form, I find the merocrine type of secretion prevailing and an absence of epithelial regeneration associated with feeding.

In hopes of being able to study to better advantage the type of secretion and of better understanding the relation of its discharge to the intake of food, I undertook a series of feeding experiments. Larvae were placed in small glass vessels with clean tap-water and kept there without food for periods varying from one to twelve days. The larger larvae invariably pupated before the experiments could be completed, so it was necessary to use larvae which were less than half grown. Larvae that had fasted for varying periods up to twelve days were killed and sectioned for determining what changes, if any, the mid-intestinal epithelium underwent during the fasts. Likewise larvae starved for two, three, four, seven and twelve days were removed to vessels containing abundance of food, and then after feeding for periods varying from half an hour up to seven hours, they were killed and sectioned for studying the epithelial changes accompanying feeding.

From a study of the preparations made from these larvae it was found that where the fast was prolonged more than four days, the mid-intestinal epithelium became so reduced and weakened that it failed to recover even though the larva survived the fast and fed freely for a time (Fig. 40). Simpson ('01, in an unpublished paper) found a similar degeneration of the epithelial cells of the mid-intestine of Clisiocampa larvae that had fasted for five days. When the fast is prolonged four days the cells take on a distinct vacuolate appearance associated with a heavy discharge of secretion (Fig. 39). After six or seven days this vacuolate condition has disappeared and the cells become greatly reduced in height. They almost cease to excrete digestive fluids and the striate border is then more conspicuous. Aside from a continued reduction in the height of the epithelium, and a greater shriveling of the cells, no further marked changes are brought about, the cells finally dying. At no time, even after a twelve day fast, is the mid-intestine completely free from food material. As a consequence there is a constant stimulus to the excretion of the digestive secretion and as the fast is prolonged the finely granular secretion is poured out and soon comes to fill most of the space between the reduced epithelium and the food content of the canal (Fig. 39, d. sec.) In place of the secretion being stored up in the cells as in the nymphs of dragonflies, it is continually poured into the lumen. This process soon drains the cells of their vitality,

since but little real nourishment can be absorbed from the already thoroughly digested content of the canal.

With larvae that had fasted less than four days no marked changes were found in the mid-intestinal epithelium. The food content of the canal is sufficient, apparently, to sustain the larva and to stimulate the cells of the epithelium to normal activities for this period so that when a fresh supply of food is taken in normal digestion is continued (Fig. 41). From the results of these expreiments, which comprised upwards of fifty separate lots of larvae, it was found necessary to turn to the preparations of the normal feeding larvae, for the determination of the type of secretion and the relation of its discharge to the intake of food.

For some time, the changes in the mid-intestinal epithelium just preceding the casting of the larval skin were mistaken for signs of an excessive production and storing of secretions, but when series of larvae preparing to molt were studied the mistake was detected. In this larva there are four sources from which the digestive secretions of the mid-intestine are derived.

As previously noted, the gastric caecae, usually present in the higher Diptera, are replaced in Psychoda alternata by a greatly reduced caecal gland which girdles the mid-intestine in the region of the esophageal valve. The large cells of this gland produce a yellowish digestive secretion similar to that of the gastric caecae of other insects. During most active secretion of these caecal glands, the cells become swollen and finely vacuolate (Figs. 18 and 47, c. gl.) The pouch, into which the secretion is poured, becomes so completely filled that its neck appears to flare, leaving a wide exit of the secretion into the lumen. During less active secretion and excretion the cells become somewhat reduced, the vacuolation less distinct and the pouch less distended with secretion or even almost empty. This is one source of digestive secretion.

A second source is the long stretch of very large cells caudad of the esophageal valve (Fig. 2, ep.) These cells during active secretion and excretion give off a finely granular secretion. This secretion is not given off as globules or droplets but simply oozes through the thin striate border of the large finely vacuolate cells and comes to fill all the space between the epithelium and the peritrophic membrane (Fig. 42). This is perhaps the most abundant supply of digestive secretion found in the mid-intestine of this form.

Just caudad of the point where the region of large cells gives way to that of the tall slender ones, comes a group of cells which during active secretion becomes greatly elongate and protrude into the lumen. These cells are active in throwing off small spherical bodies of their protoplasm by the pinching off of their tips, which float out into the lumen to dissolve and form a third supply of digestive secretion (Figs. 43 and 44, sec. p.)

The fourth source of digestive secretion is the less elongate epithelial cells farther caudad. These cells are more granular and vacuolate next to the striate border and throw off distinct globules which collect along the margin of the striate border (Fig. 45, sec. g.) These globules seem to burst and give out a secretion similar to the finely granular material of the anterior part of the mid-intestine. The striate border becomes less distinct where the cells are actively secreting and excreting but is never completely obliterated.

The mucous cells of Leidig ('57), Frenzel ('82 and '85), Korotneff ('85), Beauregard ('86), Fausseck ('87), Mingazzini ('89), Balbiani ('90), and Simpson ('00 in unpublished paper) are present in this larva. They are scattered among the large secretory cells of the anterior region as well as among the tall slender cells of the posterior region. As compared with the surrounding cells they are truly monsters (Fig. 46, m. c.) They are connected with the basement membrane by a constricted pedicle while the distal end is enormously expanded and protrudes into the lumen. They are coarsely vacuolate throughout but especially so toward the inner end. The nucleus is scarcely larger than those of adjoining cells, and does not differ from them in the arrangement of nucleolus and chromatin material. Some writers have attributed to these cells the function of secreting the peritrophic membrane, others claim that their secretion serves as a lubricant. In the larva of Psychoda alternata these cells certainly have nothing to do with the secretion of the peritrophic membrane. The fact that the secretion of these cells resembles that from surrounding cells microscopically, that their greatest activity corresponds with that of the surrounding cells and the fact that the food, enveloped in the peritrophic membrane, is continually floated, so to speak, in digestive fluids, cause me to hesitate to accept the view that the secretion of these cells is merely a lubricant. I am inclined to believe that here we have simply specialized digestive cells.

The slender cells, of the region immediately caudad of the caecal glands, have a coarse granular and finely vacuolate structure. In some preparations a slight discharge of granular secretions is to be seen although this is more frequently absent. The striate border is only slightly developed. Between the middle and distal margin of these cells are to be found vacuoles of various sizes which inclose dark brown concretions (Figs. 19 and 47, con.) These concretions are spherical, almost completely filling the vacuoles and very dense. I have not found them in any of the other epithelial cells of the mid-intestine of this larva. They closely resemble those found by Folsom and Wells in the mid-intestinal epithelium of Collembola, and are probably waste products which are secreted and held by these cells until the molting period when they are discharged along with the cells. If my interpretation of these concretions is correct these cells have a definite excretory function.

Passing forward to the anterior region of the mid-intestine we find the cells which produce the peritrophic membrane. These cells are especially active during feeding. They appear long, club-shaped and become finely vacuolate on their inner margin. From them is discharged a finely granular secretion, which forms a narrow inner border to the cells (Figs. 18 and 47, p. m.) It is difficult to tell just where the cell-body ends and the layer of secretion begins. On the inner surface of this border a portion of it hardens to form the thin uniform peritrophic membrane which closely resembles the chitinous intima of the esophagus. From the reaction of these cells to stain it is evident that they are secreting continuously; but the underlying border of secretion is especially prominent at certain times. The course of most active secretion seems to pass along the canal like a wave, following the entrance of a new supply of food somewhat as found in dragonfly nymphs. By the time the discharge of secretions in the posterior part of the mid-intestine has reached a maximum it has begun to decrease in the anterior portion. This is the case with the cells producing the peritrophic membrane as well as those of the caecal glands.

Changes at the Molting Periods.

It is well known that, with each larval molt, the entire outer cuticula, as well as the intima of the fore- and hind-intestine and the tracheal system, are cast. Sharp ('95) maintains that the facilitation of growth by the casting of the chitinous coat is

only of secondary importance. The discharge of the chitinous coat is merely an outward sign that internal changes have been going on. Eisig ('87) suggests that since chitin is a nitrogenous substance, perhaps the casting of the chitinous coat is a means of disposing of nitrogenous wastes, to which Sharp adds that perhaps the same is true of carbonaceous wastes. If the casting of the exuviae has an excretory function associated with it and if the epithelium of the mid-intestine has an ectodermal origin, as believed by some writers, then it will be easier to explain certain morphological changes which occur in the mid-intestinal epithelium at the time of molting. The striking morphological changes undergone by insects at the time of pupation and emerging of the adult, are well known and have been given much attention by workers, but there are similar although perhaps less intensive changes at each larval molt, which have been almost entirely overlooked. We shall now consider the changes in the mid-intestinal epithelium at the time of molting.

Folsom and Wells' ('06) work on epithelial degeneration, regeneration and secretion in the mid-intestine of Collembola deals primarily with the changes in the digestive epithelium at the molting periods. The Collembola are among our most primitive forms of insects, lacking Malpighian vessels and developing without obvious metamorphosis. With this type of development we should expect to find equivalent morphological changes at the different molting periods. Conditions found in the study of a form of this generalized type will not necessarily be like those in higher forms but are suggestive for one making a study of any more specialized form.

The normal epithelium of the mid-intestine of Collembola was found to be composed of very large granular and finely vacuolate cells. At the approach of an ecdysis the cells begin elongating and the inner half becomes more vacuolate. As this vacuolation continues, any concretions and gregarine parasites present in the cells and about half of the nuclei migrate from the more dense portions of the cells into the inner, more vacuolate region. Then comes a cutting off of the inner half of the epithelium. During these changes cell walls are obliterated. A new striate border forms along the line of constriction and the inner portion of the epithelium is cast into the lumen where it is digested. To replace the nuclei lost by the sloughing off, those remaining undergo mitotic division, cell boundaries

reappear and the normal epithelium is again restored. Since the forms studied lacked Malpighian vessels, Folsom & Wells concluded that this periodical discharge of half of the epithelium with concretions, inclusions and parasites had an excretory function similar to that of the Malpighian vessels in other insects. The short inactive period preceding each molt made it possible to get any desired stage of transformation. Here we find only partial epithelial regeneration at each molting period.

We shall now consider a more specialized type of insect, one with complete metamorphosis, and see how the changes in the mid-intestinal epithelium at the time of the larval molts compare with those in Collembola at the molting periods. Mobüsz ('97) studied the changes in the mid-intestinal epithelium of Anthrenus during the larval molts and found that the same changes appeared then as at pupation, only less intensive. In the study of his preparations, which included larvae in various stages of transformation, he found a large mass of material in the lumen of the mid-intesine which he first mistook for parasites. Further studies revealed to him that this inclusion was simply the remains of the sloughed off epithelium. He was able to find various stages in the throwing off of the old cells from that in which, by muscular contraction and development of the new epithelium, the old with its basement membrane was separated from the muscular coat, to that in which it was cast into the lumen and digested leaving its residue enveloped in the resistant basement membrane. Mobüsz takes exception to Rengel's work on Tenebrio molitor ('96) where he describes the nidi as being cast off with the old epithelium and basement membrane and later making their way through the basement membrane and regaining an attachment to the muscular coat. Rengel must certainly have had faulty preparations. Mobüsz found the nidi retaining their attachment with the muscular coat and concluded that either, the cells of the nidi being embryological, no basement membrane was produced beneath them, or if produced it was dissolved so that it would slip off over them when it was cast off with the old epithelium. By multiplication the cells of the nidi quickly produce the layer of new epithelium. In fact these first changes are produced with such rapidity that Mobüsz failed to catch them in any of his specimens. The new epithelium soon developes its basement

membrane and striate border and in time the nidi take on their normal condition and the new epithelium is mature. Here we find the epithelium cast off bodily and not merely in part. In conclusion Mobüsz maintains that:

(1) At each larval molt there is a total regeneration of the epithelium of the mid-intestine.

(2) The transformation of the mature larva to the pupa, in the holometabola, is simply an intensified larval molt and we may expect the same morphological changes, although to varying degrees, perhaps, at these periods.

(3) He believes that there is not only total regeneration of the mid-intestinal epithelium but also that there are greater or less changes in the epithelium of the fore- and hind-intestine and in the muscular and adipose tissues of the larva.

The larva of Psychoda alternata on preparing to molt, ceases feeding for a short time and to a marked degree discharges the food content from the alimentary canal. Then comes a short period of inactivity followed by pronounced peristalic contractions. In the thoracic region a strong ventral flexure occurs and then peristaltic waves of contraction pass forward from the posterior end of the body. This may be repeated a number of times before the chitin bursts on the dorsum of the first two thoracic segments and the larva crawls out. As soon as the larva is free it becomes quite active and begins to feed. These outward signs of transformation are simply the culmination of the metamorphosis. The internal changes are practically completed before the larval skin is cast.

Shortly before the time of molting the mid-intestinal epithelium begins to undergo striking changes. The cells begin to elongate and protrude into the lumen. Their distal halves become distinctly vacuolate (Fig. 48). There is to be noted in the nuclei themselves some change. The chromatin usually disappears or comes to closely envelope the nucleolus. At this stage the cytoplasm and enclosed secretions of the cells stain intensely with iron haematoxylin which can be removed only by prolonged differentiation.

This stage in the metamorphosis was first observed in a larva that had fasted for three days and was thought to be due to the storing up of digestive secretions, but when other specimens from the same lot were examined and no signs of such development found and when larvae, that were known to be

ready to molt, were examined and the same identical conditions found, the theory of stored up secretions was discarded. This condition of degeneration of the mid-intestinal epithelium has also been found in some specimens collected at random for general structural work, they having been caught in the act of transformation.

A later stage shows these epithelial cells becoming more broken up by large vacuoles. The entire distal portion of the cells becomes vacuolate with strands of cytoplasm surrounding the vacuoles (Fig. 49). The vacuoles at first circular in section become irregular in shape as their size increases, while the nuclei are found moving out into the distal more vacuolate portion of the epithelium. All signs of cell boundaries are lost and the epithelium resembles a mass of ragged cytoplasm with nuclei scattered about through it. In the cytoplasm small round concretions are usually present in great abundance, especially in the more vacuolate portion (Figs. 48 and 49, con.) Gregarine parasites are seldom found within the epithelium. The nuclei degenerate unevenly. Some near the basement membrane may retain a more healthy appearance with chromatine granules and large nucleolus, while those beginning to migrate lose their chromatin. At this stage of degeneration, there appears in the lumen of the mid-intestine, surrounding the peritrophic membrane and enveloped food contents, a great mass of finely granular and deeply staining secretion which is evidently the product of the degenerating cells of the epithelium. This deposit seems to be confined largely to the posterior half of the mid-intestine where the epithelium consists of the tall slender cells. In this bluish-staining deposit are to be seen scattered remains of degenerating nuclei, especially nucleoli, which seem to be especially resistant. Scattered through this deposit are also to be found deeply staining bodies, probably concretions, and a quantity of uniform yellowish secretions, evidently a product of the degenerating cells.

This degeneration of the mid-intestinal epithelium begins in the posterior portion where the cells are long and slender and as metamorphosis advances, the process of degeneration may be traced forward to the esophageal valve (Figs. 50 and 51). When the large cells of the anterior half of the mid-intestine have become strongly vacuolate, those of the posterior part have almost completely broken down and their contents cast

into the lumen. The method, by which the midintestinal epithelium, in this form, is cast off, in no wise resembles that described for Hydrophilus, after feeding, where the epithelium with its basal chitinous layer is cast off bodily; nor is it so complete and regular as that described by Mobüsz for Anthrenus. It more nearly resembles the degeneration of the mid-intestinal epithelium of dragonfly nymphs after feeding. The individual cells themselves break down and are sloughed off rather than the epithelium in mass being cast into the lumen.

The extent to which this degeneration takes place is not always easy to determine. It can be followed to where practically all of the old nuclei have migrated out into the lumen and degenerated (Fig. 51). And where practically all of the cell content is dissolved, although for a time, at least, a quantity of the cytoplasm remains in contact with the basement membrane, which is not cast off. I am inclined to believe that this is as far as the degeneration of the mid-intestinal epithelium proceeds in this form. The old adhering cytoplasm is apparently absorbed by the newly developing epithelium.

Between the epithelium of the mid-intestine and its underlying basement membrane are to be found numerous very small regenerating cells from which the new epithelium is developed (Figs. 48, 49, 50, 51, r. c.) These small cells are extremely difficult of detection except at the time of transformation. Cell division takes place in these embryonic cells while their diameter is yet scarcely one-fifth that of the nucleus of mature epithelial cells, so that it is extermely difficult to make out the type of division, but from a study of my preparations it would seem that here we have direct cell division (Fig. 54). They may be collected in small groups or in pairs or scattered singly along the basement membrane. The first structure that can be defilitely made out is the deeply staining nucleus, but as the degenration of the old epithelium advances, a definite cell form can be distinguished. The cytoplasm at the beginning is a mere border about the nucleus, but as development advances it rapidly increases in bulk and comes to form a distinct cell body about the nucleus. By the time the old epithelium is nearly all sloughed off these new cells have come to protrude up into the adhering cytoplasm of the old cells, which they seem to absorb in part (Fig. 51, r. c.)

These conditions of degeneration and regeneration of the mid-intestinal epithelium are found in larvae previous to the casting of the larval skin. Changes at this point take place with very great rapidity so that it is easy to see how former workers came to overlook, almost completely, this degeneration and regeneration of the mid-intestinal epithelium at the larval molting periods.

In larvae, taken immediately after the casting of the skin, the new epithelium of the mid-intestine is already developed. At first the cells are low and stain deeply with iron haematoxylin (Fig. 52, ep.). The nucleoli are large and stain deeply, while the chromatin material is not distinctly made out. The cytoplasm is coarsely granular and has the appearance of being striated next to the lumen. The striate border is developed early and appears even more distinct than in later stages when the cells have begun to secrete (Figs. 52 and 53, st. b.)

The contents of the mid-intestine, not cast off before metamorphosis began, is still found to be enclosed in the resistant peritrophic membrane and occupies the central portion of the lumen. Between this central mass and the new epithelium, there is still to be found a great quantity of the finely granular yellowish product from the degenerate epithelium. Occasionally the sloughed off intima of the esophagus is found coiled about in the mid-intestine, but the degenerate epithelium of the mid-intestine is so completely dissolved that only the slightest traces of it are to be found after the skin has been cast.

In this way the epithelium of the entire mid-intestine, including the caecal glands and the group of cells which produce the peritrophic membrane, is renovated at each larval molt. As soon as the metamorphosis is completed and the skin cast off the larva resumes activity and begins to feed again. The new cells of the mid-intestinal epithelium at once respond to the demand made upon them for secretions and the larva enters upon the next stage of its development.

CONCLUSIONS.

The alimentary canal of the larva of Psychoda alternata is a generalized one in conformity with the habits of the larva. Both the fore- and hind-intestine are relatively short while the mid-intestine makes up at least two-thirds of the entire length of the canal.

Longitudinal muscles are absent in the fore-intestine and in the colon and rectum.

Gastric caecae are replaced by a caecal gland, which girdles the median portion of the esophageal valve.

There are five Malpighian vessels of similar form and structure, two extending cephalad and three caudad.

The rectum is prolonged into four slightly eversible papillae, which are homologous with the anal tracheal gills of Culex and related forms.

The epithelium of the mid-intestine is divided into five distinct regions; an anterior one giving rise to the peritrophic membrane, a caecal gland, a small area of long glandular cells, a long stretch of large polygonal cells, and the posterior region of tall slender cells. The so-called mucus cells are abundant. There is no regeneration of the epithelium of the mid-intestine at the time of feeding. During a fast, secretions are not stored up in the epithelial cells but are continually poured out and if the fast be prolonged the cells may completely break down. The peritrophic membrane is secreted by a definite group of cells at the anterior end of the mid-intestine.

At each larval molt the epithelium of the mid-intestine is completely renewed. The old cells are not cast off as a whole, but the degeneration begins next to the lumen and continues until the whole cell is broken down. This degeneration begins in the posterior region of the mid-intestine and proceeds forward.

Regeneration is from scattered embryonic cells which lie in the angles at the base of the epithelial cells. The regenerated epithelium of the mid-intestine is mature by the time the larval skin is cast off.

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LIST OF ABREVIATIONS.

a. p., anal papillae.
b. c., blood corpuscles.
b. m., basement membrane.
br., brain.
c., concretion bearing cells.
c. gl., caecal gland.
c. m., circular muscles.
col., colon.
com., commissure.
con., concretion.
d., salivary duct.
d. c., degenerating cells.
d. sec., digestive secretion.
ep., epithelium.
eph., epipharynx.
es., esophagus.
es. v., esophageal valve.
f., food.
gl., gland which secretes the peritrophic membrane.
hy., hypopharynx.
il., ileum.
il. v., ileal valve.
in., intima.
l., lumen.
la., labium.
l. m., longitudinal muscles.
lr., labrum.
m., mouth.
m. c., mucus cell.
md., mandible.
m. int., mid-intestine.
m. t., Malpighian tubule.
mx., maxilla.
mx. p., maxillary palpus.
n., nucleus.
nl., nucleolus.
n. m., nuclear membrane.
p., caecal gland pouch.
ph., pharynx.
ph. b., pharyngeal bars.
ph. m., pharyngeal muscles.
pr., press of salivary duct.
r. c., regenerating cells.
rec., rectum.
s., blood space.
sec. c., secretory cells.
sec. p., secretory proliferations.
s. g., salivary gland.
sp., sphincter.
st. b., striate border.
vac., vacuole.
v., valve between ileum and colon.

EXPLANATION OF PLATES.

Plate XLIV.

1. Alimentary canal in surface view.
2. Longitudinal section of alimentary canal.
3. Mouth parts.
4. Anterior end of larva with alimentary canal and nervous system in situ.
5. Longitudinal section through the anterior portion of the head.
6. Transverse section through the anterior end of the pharynx. Plane of section sloping slightly dorso-caudad.
7. Transverse section through the median portion of the pharynx. Plane of section sloping slightly dorso-caudad.
8. Portion of the transverse section through the pharynx in the region of the large lateral pharyngeal muscles.
9. Transverse section through the caudal region of the pharynx.
10. Transverse section through the anterior region of the esophagus.
11. Transverse section through the anterior end of the esophageal valve. Plane of section sloping slightly dorso-caudad.

Plate XLV.

12. Longitudinal section of salivary gland.
13. Transverse section through the middle of the esophageal valve. Plane of section sloping slightly cephalad to the right.
14. Longitudinal section of esophageal valve.
15. A portion of longitudinal section of esophageal valve.
16. Longitudinal section of cephalic end of esophageal valve showing a portion of the blood space.
17. Longitudinal section through the tip of the infolded portion of the esophagus, showing chitinous spines.
18. A portion of a longitudinal section through the region of the caecal gland.
19. Cells with enclosed concretions, from the region immediately caudad of the caecal gland.
20. Longitudinal section through the region at which the concretion-bearing cells give way to the large polygonal digestive cells.

Plate XLVI.

21. Transverse section of mid-intestine through the region of large polygonal digestive cells.
22. Longitudinal section through the region at which the polygonal cells give way to the tall slender ones.
23. Transverse section of mid-intestine through the region of tall slender cells.
24. Longitudinal section through the region of tall cells.
25. Transverse section through the region at which the Malpighian vessels join the alimentary canal.
26. Longitudinal section through the same region.
27. Transverse sections of Malpighian vessels. (a and b) Through the pigmented secretory portions, (c) through the basal reservoir.
28. Transverse section of the ileum immediately caudad of the Malpighian vessels, showing absence of circular and longitudinal muscles.
29. Longitudinal section of the anterior portion of the ileum.

PLATE XLVII.

30. Transverse section through the ileum just cephalad of the ileal valve.
31. Longitudinal section through the ileal valve.
32. Transverse section through ileum, caudad of the ileal valve.
33. Longitudinal section through the valve between the ileum and colon.
34. Transverse section through the valve between the ileum and colon.
35. Transverse section through the colon.
36. Portion of longitudinal section through the colon.
37. Transverse section through the rectum.
38. Longitudinal section through the rectum and anal papillae.

XLVIII.

Epithelial secretion and regeneration (with 1-12 immersion.)

39. Epithelial cells of the mid-intestine of a larva after a four days' fast.

40. (a) Epithelial cells of the mid-intestine of a larva after a seven days' fast. (b) Same after feeding half an hour.

41. Epithelial cells of mid-intestine of a larva that had fasted two days then fed for half an hour.

42. A single large polygonal digestive cell from the anterior portion of the mid-intestine.

43. Tall slender epithelial cells discharging digestive proliferations.

44. Same, from region slightly cephalad of (43).

45. Epithelial cells from the posterior region of the mid-intestine discharging globules of digestive secretion.

46. Mucus cells from posterior region of mid-intestines.

47. Longitudinal section through the caecal gland.

48. Epithelial cells from the anterior portion of the mid-intestine shortly before molting, showing the first stage of epithelial degeneration.

49. Epithelial cells showing a later stage of degeneration.

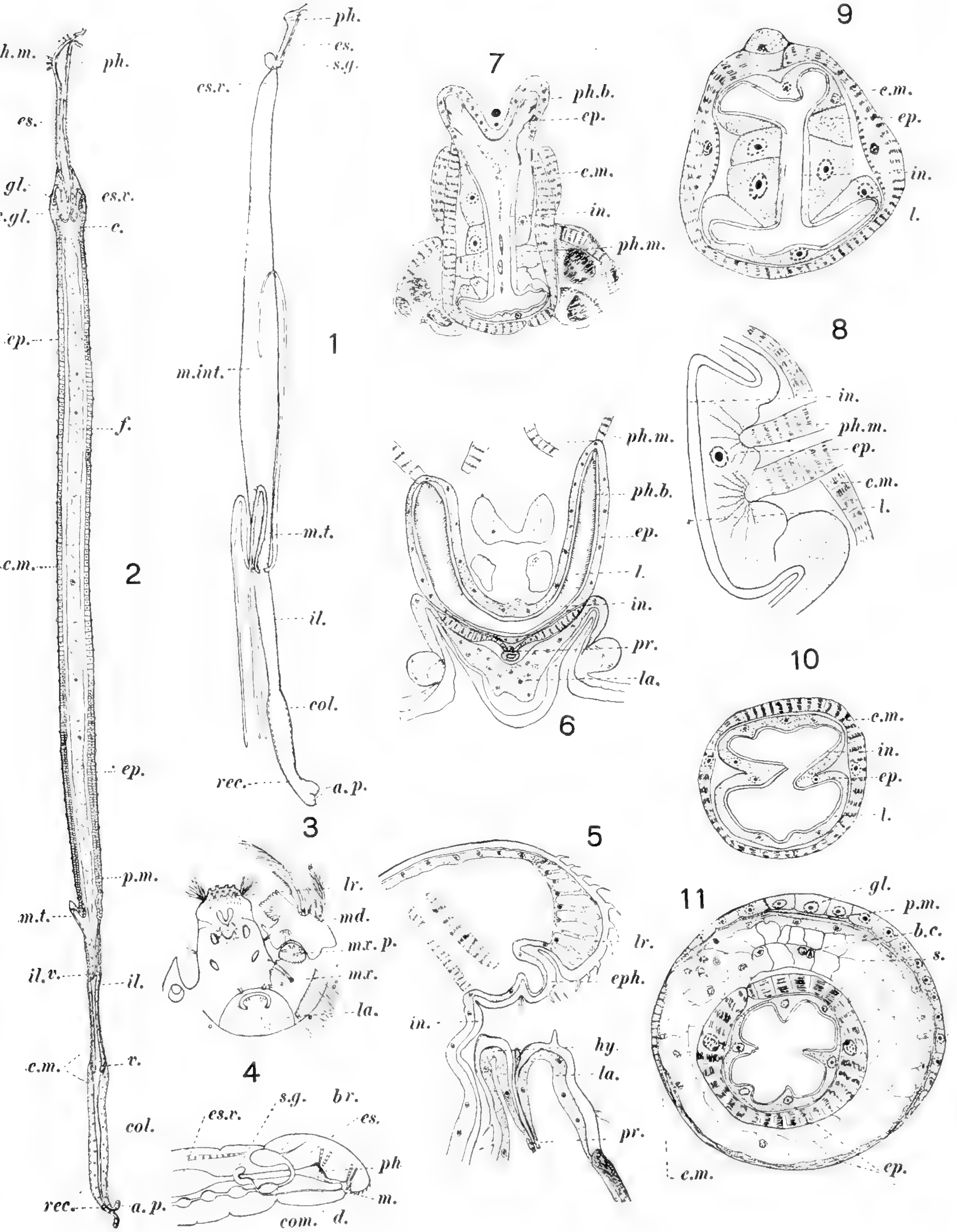
50. Epithelial cells from anterior portion of mid-intestine showing the process of degeneration well under way.

51. Epithelial cells from the same larva, but from the region of tall slender cells with degeneration almost complete.

52. Newly regenerated epithelium of the mid-intestine of a larva that had just emerged from the larval skin.

53. Epithelium of the mid-intestine of a larva that had molted less than a day previous to killing.

54. Embryonic cells in various stages of development.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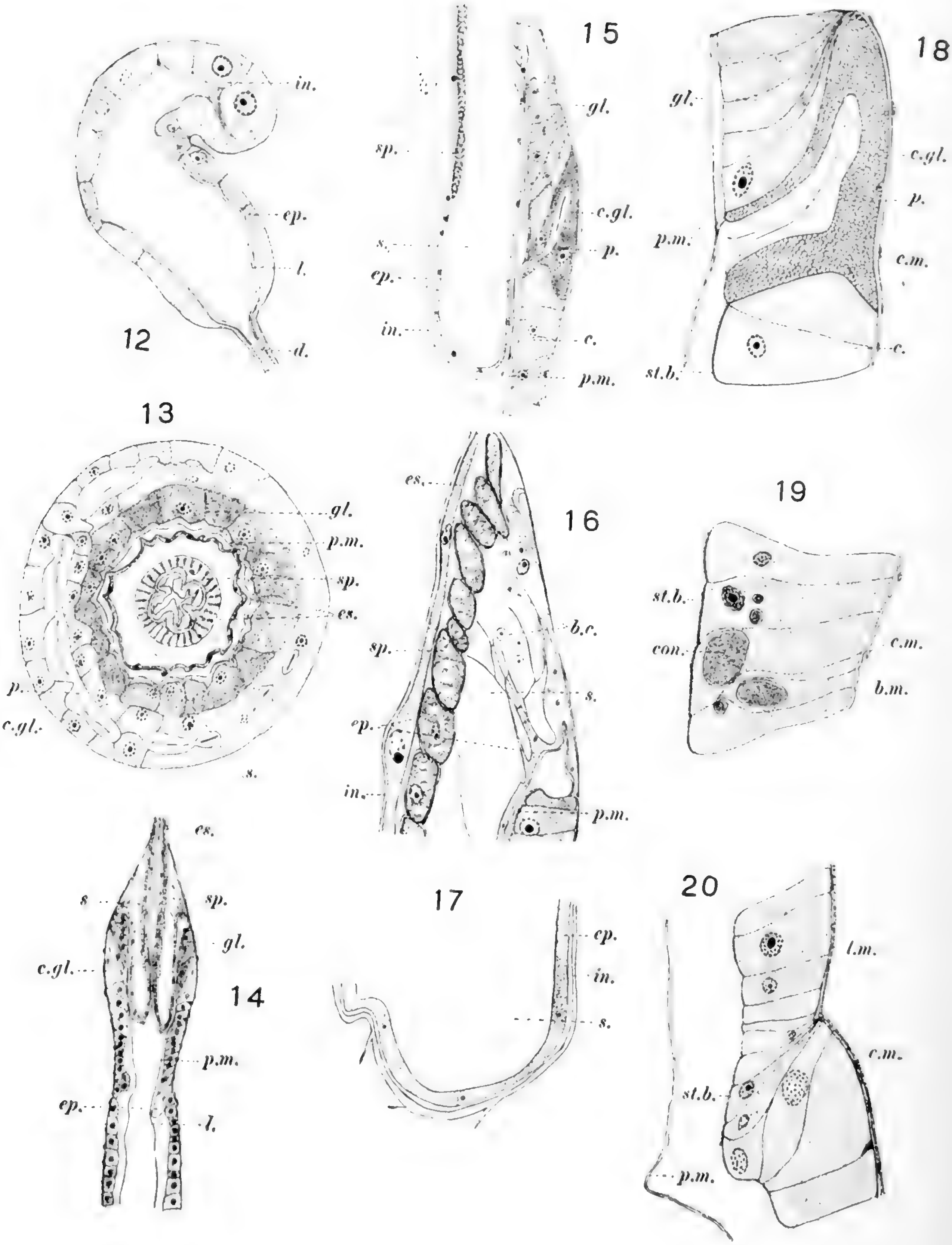
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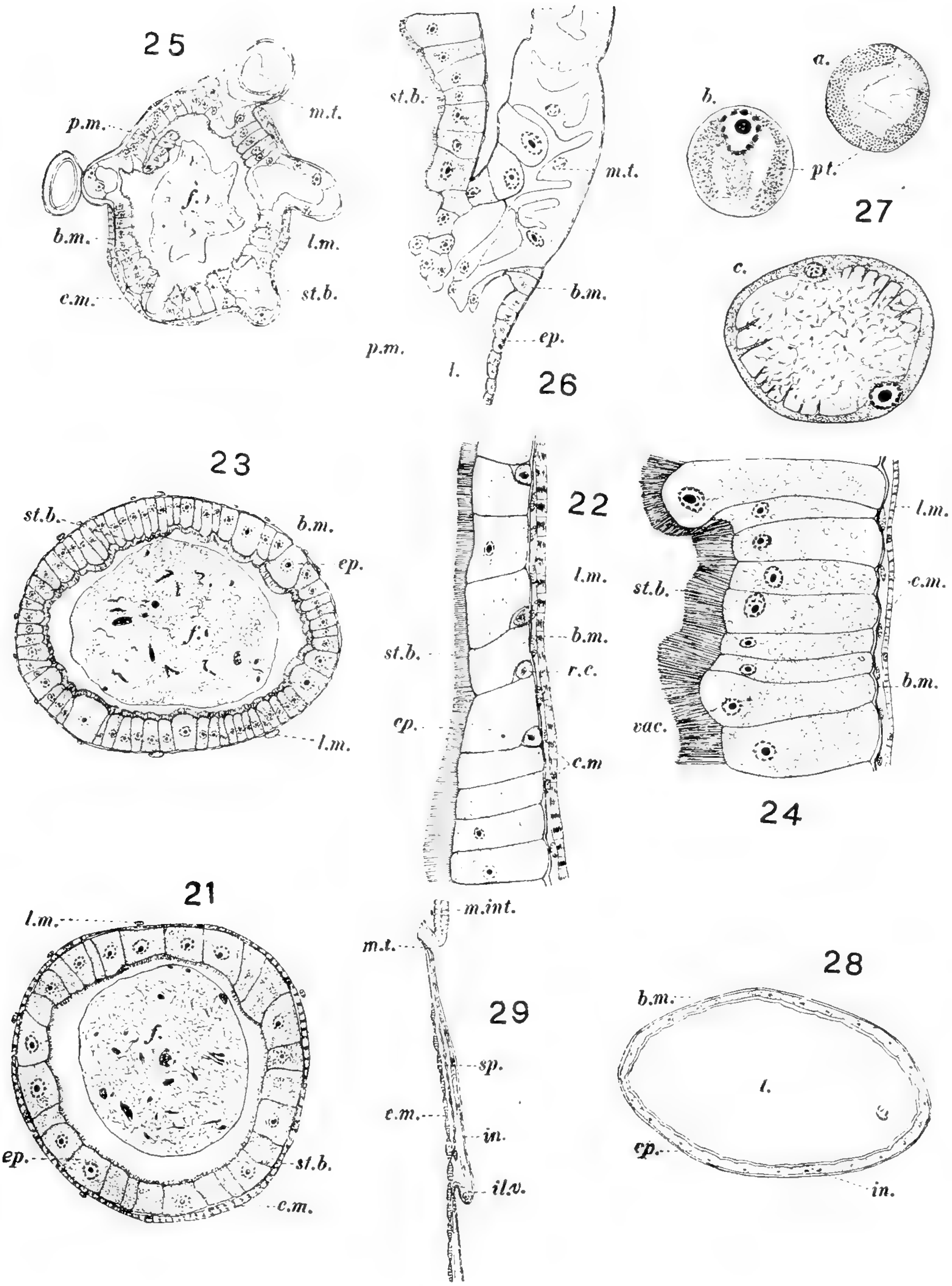
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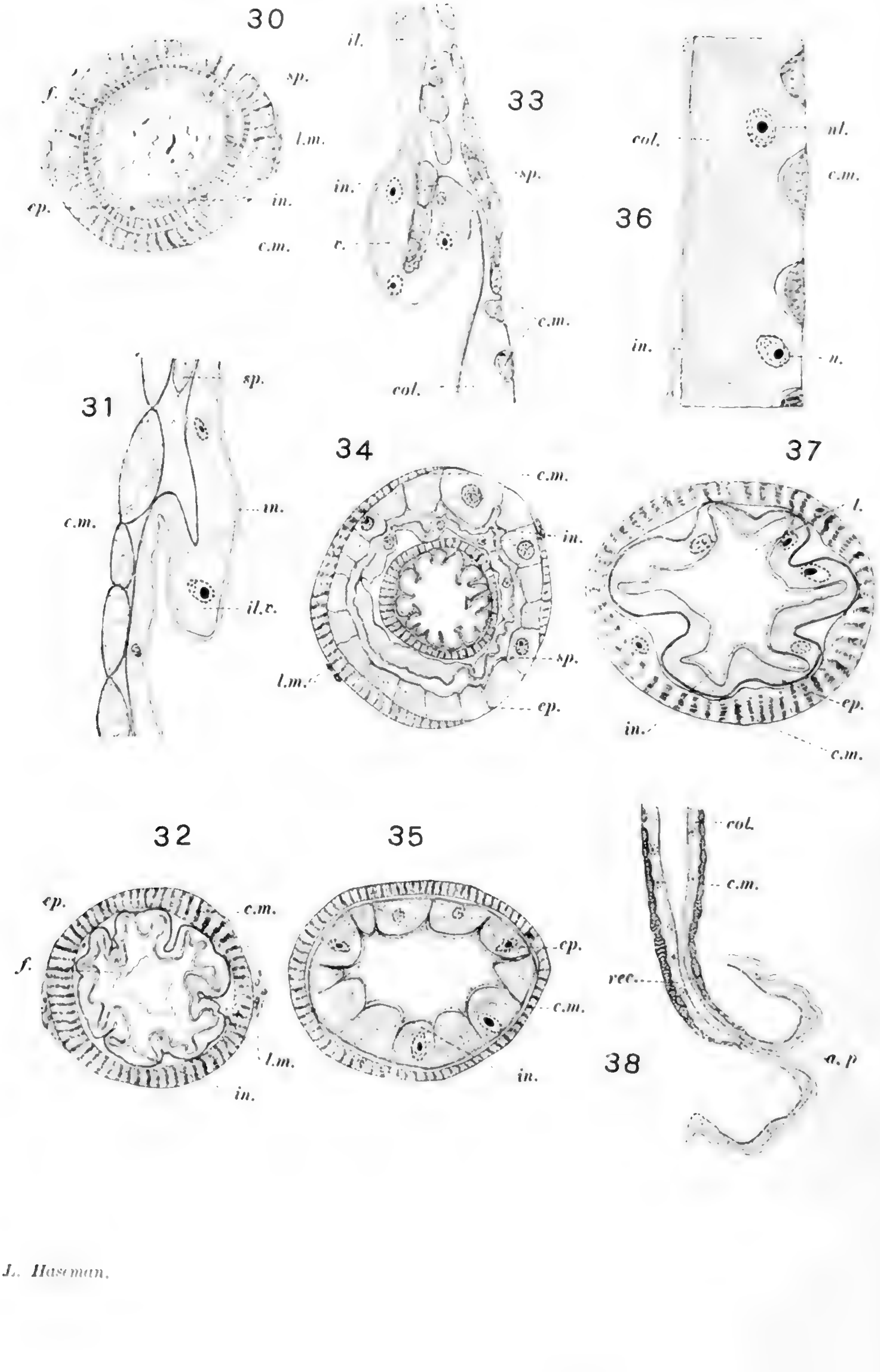
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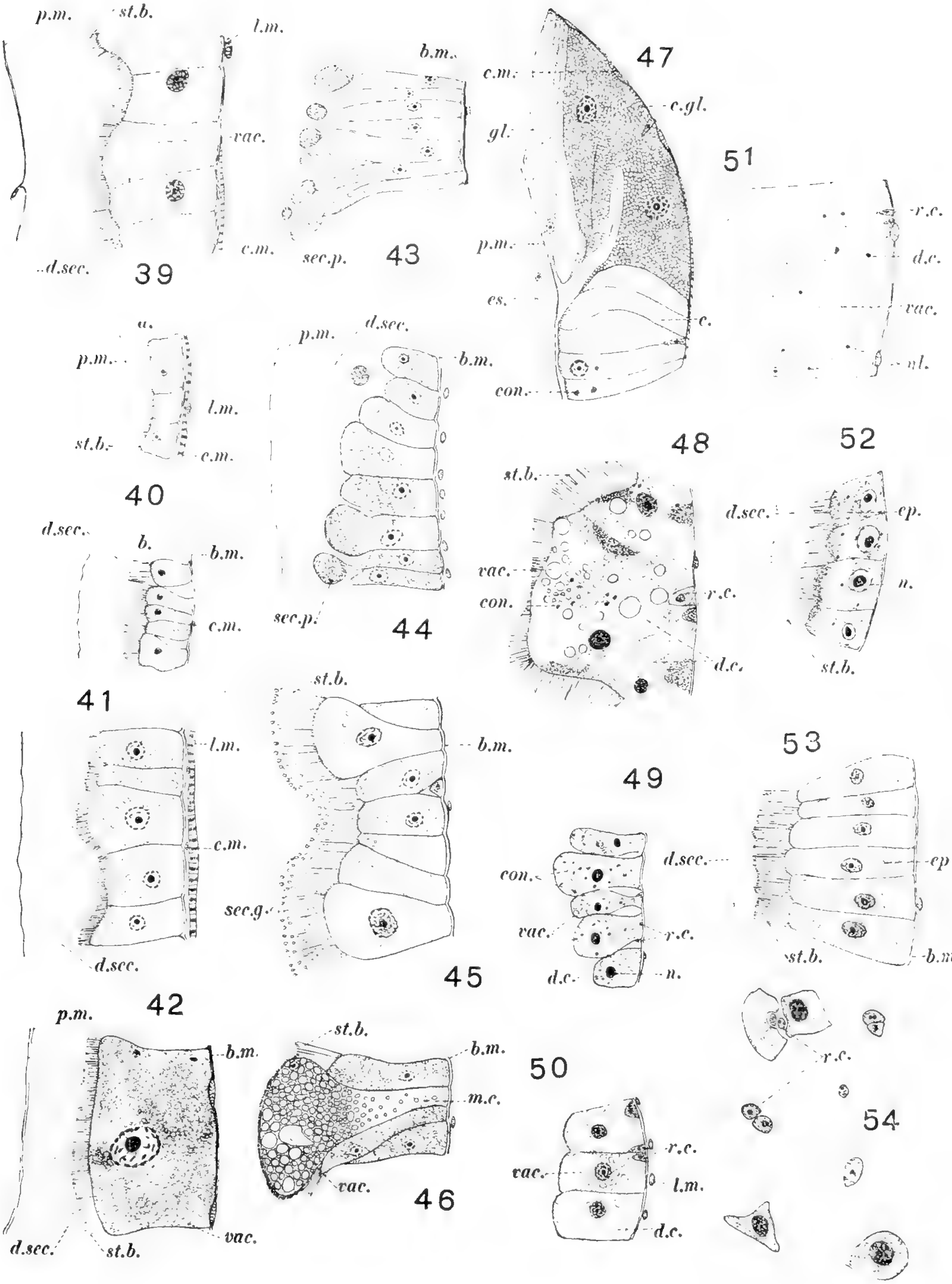
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A KEY TO THE GENERA OF THE SUBFAMILY APHIDINAE AND NOTES ON SYNONOMY.

By H. F. Wilson,
Oregon Agricultural College.

The following paper is not as complete as the author would like to have it as type species of four recently formed genera are not available. Several attempts have been made to secure the desired species without success and as there does not seem to be much chance of securing them in the near future copies of the original keys are included in this paper. All of them were made by Del Guercio and three of them are given as a division of the so called genus *Aphis.*

The first three are given in Redia (vol. 4, pp. 190–192, 1907) with the following key.

1. *Femine partenogeniche attire ed alate sprovviste di codetta o con questa affatto rudimentale.*
   Gen. Anuraphis *Del Guercio*
   (Sp. tip. *Aphis pyri* Koch).
   Femmine attere ed alate con codetta distinta................2
2. *Codetta costantamente piu corta dei sifoni.*
   Gen. Aphis *Linne*
   (Sp. tip. *Aphis sambuci L.*)
   Codetta constantamente eguale, o piu lunga dei sifoni......3.
3. *Codetta piu lunga dei sifoni.*
   Gen. Uraphis *Del Guercio*
   (Sp. tip. *Aphis genistae* Kalt.)
   Codetta della stessa lunghezza dei sifoni.
   Gen. Microsiphon *Del Guercio*
   (Sp. tip. *Aphis tormentillae* Pass.)

The fourth was published two years later (Rivista di patologia X Vegetale anno IV Num. 11. Agosto 1909. pp. 4–5.) This species is given as the dividing line between *Anuraphis* Del Guercio and *Myzus* Passerini.

A. *Codetta verricuforme, rudimentale o nulla.*
   I. *Femmine attere con tubercoli frontali nulli, in ogni caso evidentemente piu corti della meta della fronte; antenne corte col primo articolo subeguale al secondo.*
   Gen. Anuraphis *Del Guercio.*
   II. *Femine attere con tubercoli frontali piu lunghi della meta del margine della fronte fra essi compressa: primo articolo del antenne, che sono lunghe, due volte piu lungo del secondo.*
   Gen. Macchiatiella *Del Guercio.*

AA. *Codetta ben distinta*
   Gen. Myzus *Passerini.*

In working up synonomy from a standpoint of literature there seems to be a great difference of opinion. However since an International Code has been established there seems to be but one correct plan and if followed in all cases the troubles of the systematist must soon disappear. One of the rules of the code in substance states that if a number of species belonging to distinct different genera are arranged under a certain genus without a type being set by the maker of the genus then the type may be any one of the original species. If all the species but one are removed without a type being set then the last species is the type.

In 1758 Linnaeus formed the genus *Aphis* without setting a type. In this genus he included a large number of species which have been placed in various different genera, and *Aphis sambuci* is now generally taken as the type of the original genus. In 1801 Lamarck* set *Aphis ulmi* as the type and *Aphis sambuci* was not set until a year later by Latreille.†

Aphis ulmi L. is the species generally known as *Tetraneura ulmi* DeGeer. This species was first described and figured by Reaumer previous to the 10th Edition of Linnaeus. Linnaeus and DeGeer give the same citation, so the species does not belong to DeGeer. *Schizoneura ulmi* Linn. is the species designated by himself as *Chermes ulmi.*

The author of this paper will not at this time attempt to say that any of the above names should be changed, but it seems that a decision of some kind as to the disposal of the above should be made.

In making the key type species of each genera were used and more or less detailed descriptions taken of the external characters. In several instances wide variations were noticed among the species included in certain genera and some were separated to form new genera.

In studying closely related genera the development of external characters may be placed in five divisions. 1. The antennae and spur. 2. The antennal tubercles. 3. The development of the nectaries. 4. The development of the cauda. 5. The development of the wing venation. In a group of insects as pliable as the present one, any one or two of these characters

*Systeme des animaux sans vertebres, ou Tab. gen. classes, des orders et generes animaux A. Paris, an. IX, p. 300. 1801.

† Histore Naturelle Gen. et par. Des Crus. et Ins. Tome III, p. 264. 1802.

may be either under or over developed and it is necessary to place the genera according to the greatest development. Of all the characters which show this variation the wings show what may be true of all the characters.

Along these lines the subfamily has been divided into three tribes as follows:

A. Nectaries nearly as long as the body and with long hairs......**Trichosiphini.**
Nectaries without hairs and not more than half as long as the body........B.

B. Nectaries variable in length but at least one fourth the length of the body. Antennae as long as the body or longer and set on distinct antennal tubercles. The antennae of Phorodon are shorter but the tubercles are greatly developed.. **Macrosiphini.**
Nectaries variable in length; antennae usually shorter than the body and not set on distinct antennal tubercles. When tubercles are present antennae and nectaries are much reduced.............................**Aphidini.**

Tribe Trichosiphini

This tribe is limited to two genera both of which are found in the Asiatic Islands. The nectaries are quite remarkable in that they are covered with long hairs. In other respects they are not so different from the genera of the other two tribes.

I. Antennae not longer than the body and the cubital vein twice forked. **Trichosiphum.**

II. Antennae longer than the body and the cubital vein with but one fork. **Greenidea.**

Gen. **Trichosiphum** Pergande

type *anonae* Pergande.

Antennae about as long as the body, six, segmented, and fixed on large tubercles; spur of sixth segment shorter than third segment; first segment gibbous. Antennal tubercles slightly tapering but not gibbous being oblique to the forehead which is nearly flat. Body elongate and narrow; stigma of wing long and slender; cubitus twice forked. Nectaries as long as the body cylindrical, and standing out at right angles to the body. Cauda short and triangular; anal plate short, half moon shaped. Antennae, legs, and nectaries as well as the body covered with long bristle like hairs.

Apterous female:—Body short, robust, with antennae one half the length of the body; six segmented, with small antennal tubercles. Nectaries one fourth the length of the body and vasiform. Cauda short and broadly rounded; anal plate broad and slightly emarginated at the center. Antennae, nectaries, legs and body exceedingly hairy.

Gen. **Greenidea** Schouteden.

type *S. artocarpi* Westwood.

Antennae longer than the body and six segmented; spur of sixth shorter than the third segment; first segment slightly gibbous on the inner side. Antennal tubercles large and tapering, front of head wide and flat. Body long and slender, wings long, venation variable but usually the cubitus is but once forked. Nectaries almost as long as the body, slender and nearly cylindrical. Cauda short, broader than long and rounded at the tip; base slightly constricted; anal plate rounded. Body and appendages exceedingly hairy.

Tribe Macrosiphini

The author has divided this group from the following in order that the key may not contain too many conflicts. The division is made between species having distinct antennal tubercles and those having none or at the most indistinct tubercles. However should a certain species have distinct antennal tubercles with the other characters wanting then it would have to go in the next tribe.

I. Antennal tubercles tapering and very large, not gibbous on the inner side. II.

— Antennal tubercles gibbous or toothed on the inner side.............. III.

II. Nectaries nearly half as long as the body, cylindrical and curved... **Illinoia.**

— Nectaries at least one fourth the length of the body and vasiform. **Nectarosiphon.**

III. Antennal tubercles large, and as long on the outer side as on the inner; upper inner angle more or less gibbous. Nectaries variable.......... IV.

— Antennal tubercles prominent but not large and the inner side longer than the outer or else outer side is but a line.............................. VI.

IV. Nectaries tapering longer than the cauda which is sickle shaped. Wings regular with twice forked cubitus......................... **Macrosiphum.**

— Nectaries and cauda variable, wing venation irregular but very striking. Veins either wanting or else combined............................... V.

V. Antennal tubercles with sharp upper inner angle, cauda shorter than the nectaries and tapering. Stigmal and cubital vein almost meet in a broad dark band, giving the wing the appearance of having a closed triangular cell.. **Idiopterus.**

— Antennal tubercles with small round tubercle at upper inner angle. Nectaries tapering and slightly longer than tapering cauda. Wing venation variable but usually with the cubitus once forked, and the hind wing with but a single oblique vein................................ **Microparsus.**

— Antennal tubercle with small rounded tubercle at upper inner angle. Nectaries constricted at the middle and tip. Wing venation variable but usually the stigmal and cubital veins are partly joined and form a distinct closed cell with four sides.................................... **Pentalonia.**

VI. Antennal tubercles short but not wedge shaped. Cauda large and long. VII.

— Antennal tubercles wedge shaped with the inner side formed into a tubercle or tooth. Cauda short.. VIII.

VII. Antennal tubercles slightly gibbous. Antennae much longer than the body, nectaries strongly clavate. Wings with cubitus twice forked. **Amphorophora**

Antennal tubercles as in the above genus. Nectaries tapering, wings with the cubital vein having but a single fork...................... **Toxoptera**

VIII. Antennal tubercles with a strong tooth on the inner side. Nectaries almost cylindrical but tapering slightly. Cauda short and tapering. **Phorodon**

— Antennal tubercles with a prominent blunt projection forming the inner side. Nectaries slightly clavate, cauda tapering and with a knobbed tip. **Rhopalosiphum**

Antennal tubercles with a distinct but not prominent blunt projection forming the inner side of the tubercle (more prominent in the apterous forms). Nectaries cylindrical and slightly curved at tip. Cauda short and tapering, being almost triangular in form...................... **Myzus**

Gen. **Illinoia** new genus
type *M. liriondri* Monell

Antennae longer than the body, six segmented, and situated on prominent tubercles; spur of sixth segment as long or longer than the third; first segment strongly gibbous on inner side. Antennal tubercles and inner side not gibbous but tapering. Body elongate, wings long and medium stout; cubitus twice forked. Nectaries almost as long as the abdomen, broad at the base and tapering, being strongly constricted for a short distance back of the tip. Tip curved outwardly. Cauda ensiform, about one third the length of the abdomen and constricted in the middle. Anal plate broad and bluntly angled.

Gen. **Nectarosiphon** Schouteden
type *M. rubicola* Oestlund.

Antennae longer than the body, six segmented, and placed on fairly prominent tubercles; spur of sixth segment shorter than the third segment, first joint slightly gibbous on inner side. Front of head flat and narrow, Body elongate, wings large, nectaries about one fourth the length of the body with distal half dilated. Cauda one half the length of the nectaries and tapering. Anal plate triangular.

Gen. **Macrosiphum** Passerini
type *A. rosae* Linn.

Antennae six segmented, longer than the body and situated on fairly prominent tubercles; spur of sixth segment longer than third, first segment about as long as broad. Antennal tubercles slightly gibbous on the inner side. Inner surfaces at right angles to the head; forehead flat. Wings long, cubitus with two forks. Nectaries about one fourth the length of the body and tapering. Cauda as long as the nectaries and ensiform.

Gen. **Idiopterus** Davis

type *nephrelepidis* Davis.

Antennae about one and a half times as long as the body and placed on prominent tubercles; segments one and two large, the remaining segments long and slender, spur of sixth segment longer than the third. Antennal tubercles much larger than the second segment and with the upper inner side sharply angled. Body elongated, wings with the stigmal vein deeply rounded almost touching the discoidal and both lying in a broad dusky band. This gives the wing the appearance of having a closed triangular cell. Nectaries about one fifth the length of the body, straight and cylindrical. Cauda nearly as long as the nectaries and tapering.

Gen. **Microparsus** Patch

type *variabilis* Patch.

Antennae longer than the body and placed on prominent tubercles, spur of sixth segment longer than the third. First segment large and gibbous on the inner side. Antennal tubercles close together, head flat in front and merging into the tubercles. Wings long, cross veins heavy and cubitus usually with a single fork; stigma long and slender, hind wing with but a single cross vein. Nectaries about one fifth the length of the body and tapering. Cauda as long as the nectaries and broadly tapering. Anal plate slightly broader than the base of the cauda and triangular.

Gen. **Pentalonia** Coquerel

type *nigronervosa* Coq.

Antennae slender, longer than the body and placed on prominent tubercles; spur of sixth segment longer than the third, first segment strongly gibbous. Antennal tubercles gibbous at the upper inner edge. Body short and robust, wings long and with the oblique veins nearly at right angles to the costa; cubitus twice forked and at or slightly beyond the second fork combines with the radial sector, thus forming a closed cell; veins dark, hind wing with but a single cross vein. Nectaries about one-fifth the length of the body, and constricted in the middle and just behind the tip. Cauda but a knob situated on a broad base as in *Callipterini*. Anal plate broad with apex parallel to the base.

Gen. **Amphorophora** Buckton

type *ampullata* Buckton.

Antennae longer than the body and placed on prominent tubercles, third segment shorter than the spur of the sixth; first segment slightly gibbous on the inner side. Antennal tubercles on inner side rounded. Head broad in front and almost flat. Body elongate, abdomen stout. Wings large and regular, nectaries about one fourth the length of the body and very strongly vasiform. Cauda two thirds the length of the nectaries and tapering. Some species with cauda constricted about the middle.

Gen. **Toxoptera** Koch

type *aurantiae* Koch.

Antennae about as long as the body and placed on small but distinct tubercles, third segment shorter than the spur of sixth; first segment gibbous on the inner side. Body elongate, wings long and slender with the cubital vein having but a single fork. Nectaries one sixth the length of the body and cylindrical. Cauda nearly as long as the nectaries and ensiform. Anal plate broadly rounded.

Gen. **Phorodon** Passerini

type *A. humuli* Schrank

Antennae nearly as long as the body and placed on prominent tubercles, third segment longer than the spur of the sixth; first segment strongly gibbous. Antennal tubercles bearing a long tooth on the inner side, in the apterous forms this is more developed. Forehead narrow with a small tubercle bearing a frontal ocellus. Body elongate, wings long and broad with cubitus twice forked. Nectaries about one sixth the length of the body, cylindrical, and with a slight taper at the base. Cauda one half the length of the nectaries, broad at the base and tapering to a sharp point. Anal plate broadly rounded.

Gen. **Rhopalosiphum** Koch

type *A. persicae* Sulzer.

Antennae slightly longer than the body and placed on prominent wedge shaped tubercles, third segment about the same length as the spur of the sixth; first segment gibbous on the inner side. Antennal tubercles with a blunt tooth on the

inner side, the whole tubercle appearing as a wedge inserted between the head and the first antennal segment. Forehead narrow, outer edge of tubercles appear constricted. Body elongated, wings long. Nectaries about one fourth the length of the body and clavate at the outer end, cauda short, anal lobe broadly rounded.

Gen. **Myzus** Passerini

type *A. cerasi* Fabricius.

Antennae about as long as the body and situated on distinct tubercles, third segment as long as spur of sixth; first segment strongly gibbous. Antennal tubercles strongly gibbous on the inner side. Body robust, wings long and broad with cubitus twice forked. Nectaries about one fourth the length of the body, cylindrical, slightly constricted near the tip and slightly curved outward. Cauda less than half the length of the nectaries and tapering. Anal plate broadly rounded.

Tribe Aphidini

The characters which separate this tribe from the previous are taken as follows. Antennae shorter than the body, or when as long as the body nectaries and cauda very short. Antennal tubercles, when present, are indistinct or else the nectaries and cauda are small. When nectaries are very long or large the development is limited and the other characters are used to place the genera. *Liosomaphis* has large nectaries but the antennae and cauda are very short. *Mastopoda* has the antennae more developed than other genera but the tubercles are wanting.

I. Nectaries strongly clavate..II.
— Nectaries tapering and long..III.
— Nectaries cylindrical and long..IV.
— Nectaries very short or obscure..V.
II. Antennae shorter than the body, spur of sixth segment not longer than third segment. Nectaries long and strongly clavate on one side. **Liosomaphis**
— Antennae slightly shorter than the body and with the spur of sixth segment much longer than third segment. Nectaries slightly swollen throughout the outer half..**Hyadaphis**
III. Antennae about as long as the body, nectaries long and tapering and longer than the cauda..**Aphis**
— Antennae shorter than the body, nectaries short and tapering and nearly half as wide as long. Cauda short but as long as the nectaries. **Pergandeida**
IV. Antennae as long as the body, nectaries nearly one fourth the length of the body. Tarsi and claws atrophied..**Mastopoda**

Antennae much shorter than the body, nectaries slightly constricted at the tip. . . . . **Coloradoa**
Antennae shorter than the body and with but five segmented antennae. Nectaries short and cylindrical. . . . . **Cerosipha**
V. Nectaries prominent and readily distinguishable. . . . . VI.
— Nectaries very small and obscure. . . . . VII.
VI. Antennae shorter than the body, nectaries very stout and tapering. Cauda short and thick. . . . . **Pergandeida**
Antennae shorter than the body, nectaries very short in above but slender and swollen in the middle . . . . **Hyalopterus**
VII. Antennae much shorter than the body, nectaries cylindrical and as broad as long. Cauda much longer than the nectaries and tapering. . **Brachycolus**
Antennae longer than the body, nectaries barely distinguishable, the end being trumpet shaped. Cauda not as long as wide and triangular. **Microsiphum**
Antennae shorter than the body, nectaries little more than raised rings, and not flanged like the preceding genus. **Cryptosiphum**

Gen. **Liosomaphis** Walker

type *A. berberidis* Kaltenbach

Antennae shorter than the body and with indistinct antennal tubercles, spur of sixth segment about the same length as the segment; first segment gibbous on the inner side. Body elongate, abdomen robust, wings long and broad, cubitus twice forked. Nectaries about one fourth the length of the body and strongly clavate. Cauda less than one half the length of the nectaries and sharply tapering. Anal plate broadly rounded.

Gen. **Hyadaphis** Kirkaldy

Syn. *Siphocoryne passerini* preoccupied.

Antennae nearly as long as the body, third segment shorter than the spur of the sixth. Head with a slight projection at the inner base of each antenna. Body elongate, wings long and broad, venation regular. Nectaries about one fourth the length of the body and clavate in the middle. Cauda triangular short and rounded at the tip. Anal plate broad half moon shaped.

Gen. **Aphis** Linnaeus

type *A. sambuci* Linn.?

Antennae as long as the body, spur of sixth segment three times as long as the segment and as long as the third segment. Body elongated, abdomen robust. Wings broad and stout, with cubitus twice forked. Nectaries about one fourth the length of the body, somewhat slender and tapering. Cauda one fourth the length of the nectaries, stout and set on a broad base. Tip broadly rounded.

Gen. **Mastopoda** Oestlund

type *pteridis* Oestlund.

Antennae about as long as the body, third segment shorter than the spur of the sixth; first segment gibbous on the inner side. Forehead nearly flat, body elongate, abdomen robust. Wings long and slender, nectaries about one fourth the length of the body and cylindrical. Cauda very short and conical, anal plate broadly rounded. The atrophied tarsi and claws of this genus are the most distinguishing characters.

Gen. **Coloradoa** new genus

type *A. rufomaculata* Wilson.

Antennae about two thirds the length of the body, third segment longer than the spur of the sixth which is only about twice as long as the sixth. Wings moderately long, nectaries one sixth as long as the body, cylindrical at the base and slightly clavate at the end as in *Rhopalosiphum*. Cauda two thirds as long as the nectaries and tapering; tip blunt. Caudal plate broadly rounded.

Gen. **Cerosipha** Del Guercio

type *passerinina* Del Guerc.

Antennae shorter than the body and with but five segments and spur, third segment longer than the spur of the fifth. Forehead nearly flat but slightly raised in the center. Body elongate, abdomen the widest part of body. Wings long, medium wide, wing venation regular with twice forked cubitus. Nectaries about one tenth the length of the body and cylindrical, with a very slight taper. Cauda slightly shorter than the nectaries and tapering to a round point.

Gen. **Pergandeida** Schouteden

type *ononidis* Schout.

Antennae about as long as the body, spur of sixth segment as long as the third segment. Forehead with a prominent tubercle supporting the frontal ocelli, and slightly raised at the base of the antennae. Body elongated, stout; wings low and broad with twice forked cubitus. Nectaries short stout and tapering. Cauda as long as nectaries and broadly rounded at the tip. Anal plate broadly rounded.

Gen. **Hyalopterus** Koch

type *aurantiae* Koch.

Antennae shorter than the body, third segment as long as the spur of the sixth; first segment strongly gibbous on the inner side. Frontal ocelli prominent, forehead slightly raised at the base of each antenna. Body long and slender, wings also long and slender with cubitous twice forked. Nectaries very short and slender, being slightly swollen in the middle. Cauda twice as long as the nectaries and tapering to a blunt point, slightly constricted near the middle. Anal plate broadly rounded.

Gen. **Brachycolus** Buckton

type *A. stellariae* Hardy.

Antennae shorter than the body, third segment as long as the spur of the sixth; first antennal joint slightly gibbous. Body slender, wings long and slender and with the cubitus twice forked. Nectaries very short, being as long as broad and cylindrical. Cauda about twice as long as the nectaries and slender, tapering to a blunt point. Anal plate rounded and not distinct from the body.

Gen. **Microsiphum** Cholodkovsky

type *ptarmicae* Cholod.

Antennae about as long as the body and set on distinct tubercles, spur of sixth segment six times as long as the segment and longer than the third segment, first segment slightly gibbous on the inner side. Forehead broad, body large and robust. Wings long and broad, cubitus twice forked. Nectaries very short, being slightly shorter than the second antennal segment and flanged at the end like that of a horn. Cauda wide, exceedingly short and triangular in form. Anal plate barely distinguishable as a broad elevation. The only American form of this genus is the species which T. A. Williams called *Cryptosiphum canadense*, taken on *Artemisae ludovicianae*.*

* Special Bull. No. 1. Dept. of Entomology, University of Nebraska, July 8, 1891.

Gen. **Cryptosiphum** Buckton

type *artemisae* Buck.

Antennae shorter than the body, spur of sixth segment shorter than the third segment and about one and one half times as long as the sixth. Forehead flat, frontal ocelli not prominent. Body robust, wings long with the cubitus twice forked. Nectaries little more than pores with the edges slightly raised. Cauda short and tapering, anal plate rounded.

All of the genera given in this paper may be found with the original citation listed in the Entomological News for April 1910, pp. 147–156.

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